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PART I.

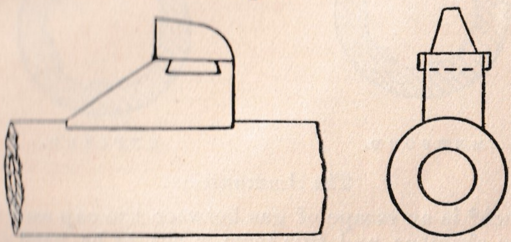
CHAPTER I.

The following definitions relate to terms used in connection with the arm itself or its ammunition. The terms used in Part II will be found defined at the commencement of that portion of the book.

The Arm.

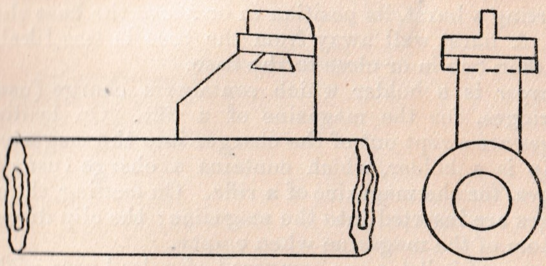
Barleycorn and *blade* are two forms of foresight used with rifles (see Figs. 1 and 2).

Fig. 1.



Barleycorn.

Fig. 2.



Blade.

The *bore* is the interior of the barrel between the front end of the chamber and the muzzle. This term is also sometimes used to denote the calibre.

The *calibre* is the diameter of the bore, measured across the lands. In England it is recorded in inches and on the Continent in millimetres.

The *chape* is the metal tip at the bottom end of a leather scabbard.

Lands are the portions of the bore left between the grooves of the rifling.

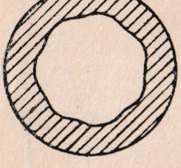
The *lead* (pronounced as the verb to lead) is the conical part of the bore just in front of the cartridge chamber. It forms a funnel to lead the bullet into the rifling.

The *locket* is the metal band round the top end of a leather scabbard.

Primary extraction is the first backward motion or loosening of the cartridge in the chamber, effected while disengaging the lugs of the bolt from their seating.

Rifling is the name given to the spiral grooves cut in the surface of the bore with the object of giving a rotatory motion to the bullet.

The following are examples of forms of grooves :—



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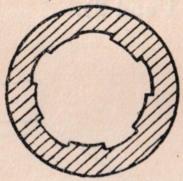

ENFIELD.

The Ammunition.

*Blow back** is an escape of gas between the cap and the sides of the cap chamber, and this term is not to be used to denote an escape of gas due to bursts or other causes.

*Burst**, in a cartridge case, as distinguished from a "Separation," may be either circumferential or longitudinal. In reporting a burst, its position in or above the base should be stated. A burst well away from the base is less likely to be serious than one in or close to the base.

A *charger* is a holder which contains a charge (usually 5) of cartridges, for the magazine of a rifle. On loading, the cartridges are swept out of the charger into the magazine.

A *clip* is a holder, which contains a charge (usually 5) of cartridges, for the magazine of a rifle. On loading, the clip and cartridges are inserted into the magazine; the clip drops out of the bottom of the magazine when empty.

A *compound bullet* is one composed of a lead core with a thin envelope or jacket of hard metal covering its nose and generally its sides.

*Fluted** cases are those in which the powder gas has got between the neck of the case and the walls of the chamber, and has forced the metal inwards.

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* These terms are to be rigidly adhered to when defects in ammunition are reported.

Leading or *metallic fouling* consist of the particles of metal detached from the surface of lead or compound bullets respectively, which adhere to the surface of the bore.

*Separations** describe bursts which are due to the stretching of the case in firing owing to excessive backward play of the lock or bolthead. Separations may be partial or complete, and may take place in any part of the case. They are distinguished from bursts by the torn edges of the metal not being fuzed. In case of doubt as to the casualty being a burst or a separation, the rifle or machine gun should be overhauled.

*Split** is a burst which occurs at the neck or shoulder of the cartridge case.

Stripping. A compound bullet is said to strip when the lead core is blown through the envelope, generally leaving the latter in the bore. This is also termed a blow through. A lead bullet is said to strip when it is blown out of the bore, across the lands, without following the rifling.

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* These terms are to be rigidly adhered to when defects in ammunition are reported.

CHAPTER II

The Introduction of Rifling. History of Rifles up to the Introduction of Magazine Arms.

The accuracy and range of firearms used in war, on which so large a part of their efficiency depends, is due to the invention of the spiral grooving of the barrel. This invention did not follow till some 200 years after the first use of firearms, while its general adoption for military purposes does not even date back beyond the middle of the 19th century.

In its essence rifling may be defined as a spiral grooving cut on the inner surface of the barrel, which causes the projectile to revolve while passing to the muzzle. The rotation thus imparted continues during flight, giving gyroscopic stability, and equalising in all directions the tendencies to erratic flight caused by irregularities of form or density.

Little is known of the early history of rifling. It cannot, however, have originated until the manufacture of firearms had reached some degree of accuracy. It seems probable that it was the invention of some individual genius, but the inventor's name is not known with certainty. It has been variously ascribed to Gaspard Kollner, of Vienna, in the 15th century, and to Augustus Kotter, of Nuremburg, in 1520. The invention certainly dates back to the first half of the 16th century, but there is no adequate evidence to carry it back to the 15th. It had certainly reached this country from the Continent by 1594.

The practice of spinning a spear or dart when thrown, or an arrow by spiral feathering to steady it in flight, was well known at an early date, and we may dismiss the often-repeated story that rifling had its origin in straight grooves, made to receive the fouling, and that by an accident these were on some occasion made spiral, and the virtue of spiral grooving thus discovered. There seems to be no evidence in support of the story. The earliest known rifle barrels have spiral grooving.

It was natural that such an invention should first be developed in connection with sporting weapons, and that its application to military weapons should not take place until it had been well proved. No systematic arming of troops with it seems to have taken place before the end of the 16th century. At the beginning of the 17th, a number of rifles were made for the use of the Danish troops under Christian IV. The Elector Maximilian is said to have introduced rifled firearms into the Bavarian Army at the end of the Thirty Years' War (Deane's "Manual of Firearms"). Marshal Puységur in the 17th century recommended that a certain number of men in each company of

the French Infantry should be armed with rifles. A rifled carbine was the arm of at least some of the French Cavalry regiments before 1680.

The practical difficulties attending the use of the rifle for service purposes were great. It required a ball fully as large as the bore, and this had to be forcibly inserted into the muzzle, and rammed down. The powder left much fouling in the bore, and this added much to the difficulty of loading. In the smooth bore harquebus or musket, on the other hand, it was customary to use a ball considerably smaller than the bore, so that the arm could be loaded without difficulty even when foul. The losses of velocity and accuracy due to this method were not very material at the short distance at which the smooth bore was effective. Rapidity of fire, then, being incompatible with the use of the rifle, the attempt to make use of it in the hands of regular troops seems to have been abandoned during the greater part of the 18th century. Mr. Grose, in his book on "Military Antiquities," written in 1786, does not so much as mention the rifle as a military arm.

The phenomena of the flight of rifled projectiles have long engaged the attention of scientific men. The earliest and best known investigator in this country was Benjamin Robins (1707–1751). He proved by careful trial that the erratic flight of a musket ball was largely due to its bounding from side to side of the barrel in its passage, and receiving from the last point which it touched not only an oblique, but a rotary motion, owing to which the deviation from the line of aim increased out of all proportion to the range. He proved, what had not been fully recognised, that a ball from a rifle travelled with the same part foremost which had been put uppermost in the barrel, and that this was due to the spin imparted by the rifling. He summed up the practical result of his observations by a very remarkable prophecy, as follows: "Whatever State shall thoroughly comprehend the nature and advantages of rifled barrel pieces, and, having facilitated and completed their construction, shall introduce into their armies their general use, with a dexterity in the management of them, will by this means acquire a superiority which will almost equal anything that has been done at any time by the particular excellence of any one kind of arms, and will, perhaps, fall but little short of the wonderful effects which histories relate to have been formerly produced by the first inventors of firearms." ("New Principles of Gunnery, 1742.")

The difficulties which have been mentioned as unfitting the rifle for war were far less serious when it was used for sport. Here accuracy was far more important, and the difference in rapidity of loading as compared with the smooth bore far less so, at least as regards European game. In the Tyrol, and in Switzerland, at all events, the rifle early came into vogue. Where steep and broken ground assimilated the conditions of war to those of sport, by preventing the movement of close

bodies of men, it was always a formidable weapon. Though we do not hear of it as being prominent in the formed European armies of the middle of the 17th century, it played its part with success in the American War of Independence, in which the hunter's weapon became of necessity a military arm. It was, perhaps, on this account that it was tried for some of the French troops by Napoleon, only to be abandoned again in 1793. It was certainly owing to Transatlantic experience, and to corps of Jägers having been recruited on the Continent to fight on the British side in America, that the military authorities of this country accepted the suggestion of Colonel Coote Manningham to raise a corps of men to be armed with the rifle, under the title of the Rifle Brigade. This corps was a success from the first. After careful trials of foreign, as well as British rifles, the Baker rifle was adopted for it. This was a rifle of 20-bore, weighing 9½ lbs., and sighted for 100 and 200 yards. The barrel was 2 feet 6 inches in length, and had seven grooves with a spiral, making one turn in 10 feet. Small wooden mallets were at first issued in order to force the ball to enter the rifling, but these were before long discarded. This rifle, like other firearms of the time, had a flint lock. A second battalion of the Rifle Brigade was raised in 1805. It was armed with an improved weapon, the Brunswick rifle, after trials by a Committee which assembled at Woolwich in 1836. In this rifle, which was of larger bore (·704-inch) than the Baker, the ignition was on the percussion principle, which had been invented by the Rev. Alexander Forsyth, M.A., LL.D., Minister of Belhelvie, Aberdeenshire, in 1805. The weight of this arm was 11 lbs. 5 oz., and it was sighted to 300 yards. There were two grooves, which were semicircular in shape; the round ball had a belt cast completely round it, and this fitted the grooves. A notch cut across the muzzle of the rifle served to guide the ball into the grooving. The spiral made one turn in the length of the barrel (30 inches); so rapid a spiral became possible owing to the good hold given by the mechanical fit of the ball to the grooves. But the difficulties caused by the accumulation of fouling were not diminished by the new system, and it was not many years before this rifle was superseded in its turn.

Meanwhile, attempts were being made in many quarters to solve, in one way or another, the problem of obtaining a close fit of the ball to the bore without having to force it in. It was evident that if the ball could be made to expand and fill the grooving after it had been dropped into the barrel, the main difficulty would be avoided. To effect this, M. Delvigne, a French infantry officer, reduced the diameter of the powder chamber, making it smaller than the bore, and leaving a square ledge at its mouth. If, now, a spherical ball, fitting the barrel easily, were pushed down upon it, and a few blows struck on it with a heavy ramrod, the ball, which was of soft lead, was slightly flattened, and at the same time

expanded into the grooving. The expansion of the ball was important, not only for accuracy of shooting, but because a loose ball was liable to be displaced, or even to roll out of the barrel if the muzzle was held downwards. With this system, the shooting showed an improvement, but the fouling in and about the chamber still made difficulties, and the deformation of the ball tended to make the shooting erratic. Matters were somewhat improved by wrapping the ball in a thin, greased patch, and placing it in a wooden sabot, which rested on the shoulders of the chamber; these modifications were introduced by Colonel Poncharra in 1833. With this method of loading the arm was used by the first company of Chasseurs-à-pied, the nucleus of the Tiralleurs de Vincennes, which was the first of the French rifle battalions.

Another method of expanding the ball, by means of the ramrod, was introduced by Colonel Thouvenin. This was to place in the centre of the breech of the rifle a small pillar of steel, round which the powder lay. The pillar formed an anvil, on which the ball was flattened out by blows from the ramrod. This invention, known as the carabine-à-tige, met with little success so long as the spherical ball was used, but the latter was soon to be superseded. The change of form from the spherical to the conical ball was the next step. It solved the problems of making loading easy, and of giving to the projectile greater ballistic efficiency.

Robins 100 years before had recommended an egg-shaped ball. Greener in 1836 produced a ball of this shape with a tapered hollow and a tapered plug of rather larger size, which being driven home by the explosion would expand the ball to the full size of the bore, but the Committee to which the invention was submitted rejected it, after some unsatisfactory trials, on the ground that the bullet was a compound one and therefore unsuited for H.M. service.* Bullets of modified form, having a hemispherical base and the fore part tapering to a point, were tried in America about this time. No very practical improvement was effected, however, by such means. It was the cylindro-conoidal bullet, with a flat hollowed base, which was destined to bring about a revolution in firearms. Such a bullet, having a flat base, had been suggested by Delvigne, and was tried by Thierry in the Delvigne rifle soon after 1830. Colonel Davidson's bullet, used by him in India in 1832 and by the Edinburgh Rifle Club in 1840, was of this kind; it had an ogival head and a cannelure near the base. A bullet of very similar shape was used by Captain Minié of the Chasseurs d'Orléans in the Thouvenin rifle, to which it was much better suited than the spherical ball. The ramrod was made with a hollow in it of the same shape as the fore part of the bullet, so as to drive it home without deformation. Many of the early pointed bullets, known

* In 1857, however, the Board of Ordnance awarded £1,000 to Mr. Greener "for the first public suggestion of the principles of expansion, commonly called the Minié principle in 1836."

as picket (peaked) bullets had a long taper forward and a very short cylindrical part in front of the base. They were consequently liable to lie askew during their passage up the barrel and in leaving the muzzle, and so to make erratic shooting. But the importance of giving the bullet sufficient hold on the rifling to centre it properly was soon understood. Captain Minié in 1849 produced a hollow-based bullet which expanded satisfactorily when fired from a flat-breeched rifle. The idea of the hollow base was not new. So long before as 1823 Captain Norton had imagined that it should be possible to expand the bullet satisfactorily by making the greater part of it cylindrical, and giving it a hollow interior large enough to contain the powder charge. This does not seem to have been a very practical invention, and it was rejected in 1824 by the Select Committee on Firearms on the ground that a spherical ball was the only shape of projectile adapted for military purposes. Minié's method of insuring expansion was to have a deep taper hollow in the base, with a small hemispherical iron cup fitting it. This was driven some distance into the hollow by the explosion, and so expanded the bullet. In this bullet there were two cannelures near the base, cut with their lower sides at right angles to the axis of the bullet and their upper sides sloping at an angle of about 45°. This was a device of Captain Tamisier's, the object being to present behind the centre of gravity an increased resisting surface to the air if the bullet were not spinning true in its flight. But it was soon found that these were not necessary. Similarly, the hollow at the base was commonly made large with the object of throwing forward the centre of gravity, a point on which great stress was laid at this time. But such devices were only necessary because the bullet was deficient in gyroscopic stability. The simple remedy for this was to quicken the spiral and so to increase the rate of spin. The hesitation in adopting this course was due (1) to the fear of the bullet stripping—a constant danger with the spherical ball—and (2) to an exaggerated idea of the loss of velocity caused by the extra friction of a comparatively rapid spiral.

The first successful expanding bullet was Minié's, and with it loading became practically as easy with the rifle as with the musket. His system was quickly adopted in one form or another by different nations. In 1851 the "English Minié" rifle was introduced into the British Army; its dimensions, &c., being as follows:—

Weight with bayonet	10 lbs. $8\frac{3}{4}$ oz.
,, of barrel	4 lbs. 10 oz.
Length of ,, ...	3 ft. 3 in.
Diameter of bore	·702 in.
Number of grooves	4.
Pitch of spiral	1 turn in 6 ft.
Diameter of bullet	·69 in.
Weight of bullet	680 grains.
,, powder	$2\frac{1}{2}$ drs.

The rifle was sighted to 1,000 yards. It was used by some of the troops in the Crimea, but was never generally issued. The first imitation of the Minié bullet tried by the military authorities was conoidal in shape, with a large hollow, and having no cylindrical part, did not centre truly in passing up the barrel. The cannelures were omitted as unnecessary. The shape was improved, and with a hemispherical iron cup at the base of the hollow, to assist expansion, it shot with fair accuracy. It sometimes happened, however, that the iron cup was driven right through the bullet, as the internal hollow was large, and the internal pressure driving the walls against the surface of the bore very great. The ammunition for this rifle was made up into cartridges; the point of the bullet lying next the part containing the powder. After pouring the powder into the barrel, the cartridge was reversed, the paper above the bullet torn off, and the bullet, which was lubricated with a mixture of five parts of tallow to one of beeswax, rammed home.

As a makeshift arrangement, a number of 1842 pattern muskets were rifled and issued to the Royal Marines. They were known as sea-service rifles, and fired a bullet of the Minié pattern ·731 inches in diameter and weighing 825 grains. The powder charge was 3 drams. Prior to this production of rifles on the Minié system, the only advance that had been made on the arms of the Rifle Brigade already described consisted in the issue to the 1st Battalion during the Kaffir War (1846–1852) of a certain number of Lancaster rifles carrying a flat-based conical bullet cast with two wings to fit the grooving. With this rifle, which was sighted to 900 yards, some useful work was done, though its accuracy was not great.

It was by this time evident that a new rifled arm was needed for the whole of the British forces. A Committee accordingly sat in 1852 for the purpose of deciding on the pattern to be adopted. They tried the rifles of several private makers against one produced at the Royal Small Arms Factory at Enfield. Lancaster's oval bore rifling (a very old invention) was not thought to give any advantage over grooves of the ordinary kind. Nor did there appear sufficient reason for adopting the increased spiral of the Lancaster or Purdey rifles. The conical expanding bullet was common to all the rifles tried except the Brunswick, which was shot alongside them and proved itself much inferior. The Committee recommended the Enfield rifle, the dimensions of which were settled as follows:—

Weight	8 lbs. 14½ oz.
Weight of barrel	4 lbs. 4 oz.
Length of ,, ...	3 ft. 3 in.
Diameter of bore	·577 in.
Number of grooves ..	3.
Pitch of spiral	1 turn in 6 ft. 6 in.
Diameter of Pritchett bullet	·568 in.
Weight of bullet	530 grains.
Charge of powder	2½ drs.

The backsight was of Westley-Richards's pattern with a hinged leaf capable of being folded down either forward or backward.

In 1853 the Pritchett bullet, having a hollow base without plug or cup to assist expansion was adopted for the Enfield rifle. The form and dimensions of this bullet had been suggested to Mr. Pritchett by Mr. Metford. In 1855, however, the form of the cavity in the base was altered, and a wooden plug inserted, to give a greater range of expansion. In 1859 the diameter of the bullet was reduced to ·55-inch, and its length slightly increased to maintain its weight. At the same time the lubrication, which had previously consisted of a mixture of beeswax and tallow, was altered, beeswax alone being used.

Alterations from the first pattern of the Enfield rifle were afterwards made as follows:—In 1854 a new backsight was adopted, the flap of which was protected when down by flanges, and when raised was kept upright by a spring. It could be folded down either forwards or backwards. In 1855 a new ramrod, with a jagged head, was adopted. In 1858 the grooving was made "progressive" in depth, decreasing from ·015-inch at the breech to ·005-inch at the muzzle.

The Enfield rifle was first issued in 1855, and was used in the Crimea, superseding the rifled musket, and the Minié. A shortened form of it having a 5-grooved barrel 2 feet 5 inches long, was made for the Rifle battalions, and very similar carbines for the artillery and cavalry. The corps of sappers and miners (now the Royal Engineers) was armed in 1855 with a Lancaster oval-bore rifle with increasing twist.

In 1858 a new short rifle of the same bore was made for the Navy, having 5 grooves of progressive twist giving one turn in 4 feet. This rifle was also issued to the Rifle battalions and to sergeants of infantry of the line; its shooting was more accurate than that of the previous patterns of the Enfield rifle.

The tendency of rifling hitherto had been towards deep grooving into which the ball was forcibly made to fit. It was either in the first place larger than the bore, and was hammered into the muzzle or forced (in the case of breech-loaders) into the grooving by the pressure of the powder gases; or else it was made smaller than the bore and expanded by hammering (as in the pillar-breeched rifle), or by the explosion of the charge. In all these cases it was desirable that the lead should be as soft as possible, and therefore unalloyed. The great tendency of the bullet, especially when of pure lead, to be driven across the lands instead of following them, in its turn encouraged deep grooving. Owing principally to the want of accurate measuring instruments, the variations of size in individual weapons of the same pattern had been such as to make it very difficult to obtain

satisfactory and uniform shooting. It was an important step when the Commander-in-Chief, Lord Hardinge, approached Mr. Whitworth in 1854 and induced him to bring his experience to bear on the subject of rifling. Though not an expert in small arms, he understood well the importance of fine measurement and accurate manufacture. After a long series of experiments he produced a rifle firing a bullet of equal weight with that of the Enfield, but, since he had reduced the bore from ·577 to ·450, the projectile was ballistically far more efficient. He had gone thoroughly into the question of the best pitch of spiral for the bullet used, and had fixed it at 1 turn in 20 inches. But the most novel feature was the form of his rifling. This was hexagonal, and although it was at first claimed for it that a cylindrical bullet would also shoot satisfactorily from it, the bullet used was also hexagonal. It was evident that stripping was impossible with such a bullet; it could not fail to follow the grooving. A soft bullet was no necessity, for the spin was given to the bullet without reference to its hardness. With this rifle some striking results were obtained. It was officially tried in 1857 against the Enfield rifle, with the following results:—

Distance.	Angle of elevation.		Mean deviation.	
	Whitworth.	Enfield.	Whitworth.	Enfield.
Yards.	° ′	° ′	Feet.	Feet.
500	1 15	1 32	0·37	2·24
800	2 22	2 45	1·00	4·20
1100	3 8	4 12	2·62	8·00
1400	5 0	..	4·62	..
1800	6 40	..	11·62	..

The rifles were fired from a fixed rest.

At 1400 yards the shooting of the Enfield rifle was so wild that no diagram could be taken. It was not fired at 1800 yards.

In spite of these successes, the Whitworth rifle was not adopted for the Service. Experiments with rifles of the reduced calibre were carried on at Enfield, but the large bore survived as the arm of the troops for a dozen years.

The fashion set by the Whitworth rifle was for a time followed by private makers, and various rifles with polygonal grooving made their appearance at the early meetings of the National Rifle Association at Wimbledon. But this system did not survive very long. Mr. Metford, C.E., attained great success in 1865 with a rifle of ·450 bore having 5 very shallow grooves, and firing a bullet of lead hardened with antimony,

and wrapped in a thin paper patch. Expansion was effected by the blow of the explosion on the base of the bullet, which was slightly hollowed. The difficulty in loading and the loss of accuracy caused by the accumulation of fouling in rifles having deep or polygonal grooving, vanished under the new system. Each shot swept out the fouling of the previous one. The accuracy of the Whitworth was quite outclassed by rifles made on this new system, in which the deformation of both the bore and the bullet from the cylindrical form was reduced to a minimum. The success of the new system was immediate. It was widely taken up both at home and abroad, and in half-a-dozen years rifles on the polygonal system had for practical purposes disappeared.

Meanwhile another most important development was in progress, one which as it was common to firearms in general, need only be outlined here. The convenience of putting in the charge at the breech and not at the muzzle end of the tube had very long been recognised. At an early date cannons were commonly so made, and ingenuity was shown in the attempt to apply the principle to portable firearms. But as a result of improvements in gunpowder and the importance of giving the projectile as high a velocity as possible, the simplicity and strength of the muzzle-loader became again indispensable. Examples of breech-loading firearms are found in museums, dating from the first half of the 16th century, and probably the attempt to produce a practical breech-loader was never abandoned for very long. In 1742 Benjamin Robins speaks of rifled barrels charged at the breech, the powder and bullet being put in through the side of the barrel by an opening which, when the piece is loaded is filled up with a screw. The attention of those interested in rifles was particularly drawn to breech-loaders, because the process of forcing the ball into the grooving from the muzzle made the rifle slow to load as compared with the musket. A breech-loader very similar to those described by Robins, was invented about 1775, by Lieut.-Col. Patrick Ferguson of the 71st Highlanders, and met with some success in his hands. But the difficulties of dealing both with the escape of gas through the joints of the action, and also with the deposit left by the charge when fired, were such that it was long before any nation adopted for military use a breech-loading system. It was not until 1841 that Prussia set the example by adopting the needle gun, invented by Dreyse in 1838. In this rifle the breech was closed by a fitting much in the form of a door bolt. Ignition was effected by a long needle contained in the bolt, which was driven forward by a spiral spring on the trigger being pulled; the needle perforated the base of the cartridge, and ignited the charge by striking a disc of fulminating material. The defects of this action were considerable. After a few rounds the rifle could not be fired from the shoulder, owing to the escape of flame. The needles rusted and broke. Yet the gain of rapidity in loading was more than enough compensation,

and the "Zundnädelgewehr" became the general arm of Prussian and German troops, and was used in the wars of 1848, 1866 and 1870.

The majority of the many forms of breech-loader invented during the first half of the 19th century, had some sort of a hinged block which turned over and gave access to the chamber in which the charge was placed. The Lefaucheux system of hinging the barrels so that they could be swung up to or away from a false breech, was eventually a success for shot guns, but was found not to be well suited to the requirements of military service. The revolving principle, a very old one, suffered from the difficulty of adjusting each chamber correctly in line with the barrel, and still more from the loss of power, caused by the leakage of gas at the opening between the chamber and the barrel. Breech-loading, so long as the charge was inserted without a cartridge, or while a self-consuming cartridge was used, was not a complete success. Not only was there difficulty in preventing leakage of the flames, but the cartridge was very easily damaged when carried on Service. In most of the breech-loaders of 1850–1860, the cap was separately seated upon a nipple, and the flame from it had to pierce the cartridge and ignite the charge. Such was the system of the Sharp's, Terry's, Greener's and Westley-Richards' carbines which were experimentally introduced into the British Army between 1857 and 1861. The Sharp's, an American rifle, was patented in this country in 1852. The breech end of the barrel was closed by a slide actuated by a lever forming the trigger guard. The slide was drawn down to allow the cartridge to be inserted, and when raised to close the breech, its sharpened top edge cut off the end of the cartridge and exposed the powder to the flash from the cap. The action of Terry's rifle was more complicated, being a modified bolt action. In this, a tallowed wad was fixed at the base of the cartridge, and the charge was ignited from the centre; the wad remained after the shot, and was pushed forward in front of the next cartridge inserted. Terry adopted the principle of making the ball larger than the bore, so that it filled the grooving when forced into the rifling. Westley-Richards's rifle had a hinged block opening forwards, and his action, like Terry's, endeavoured to meet the difficulty of the escape of gas by a felt wad at the base, serving as a gas check. The rifling of the Westley-Richards carbine was octagonal. In the Greener carbine, an American arm, the barrel was unlocked from the breech and slid forward. The escape of gas was controlled by a sliding tube having a tapered ring at its hinder end, which acted as an obturator. It was a great improvement on the disc of copper or soft metal designed to serve the same object and patented in this country by the Frenchman Pauly, in 1814, and by Sears in 1850. But the breech-loader was not an undoubted success until the adoption of the metallic cartridge containing its own ignition, solved in the simplest way the problem of rendering the chamber gas tight.

In view of the military success of the needle gun, the adoption of a breech-loading system became of immediate importance to all nations. The French adopted the Chassepôt in 1866. This was a rifle of ·434 calibre with bolt action. The cartridge was self-consuming and had a cap in the centre of the base, and on the face of the bolt there was an indiarubber washer to check the escape of gas. Fouling was a great difficulty with this rifle. The attention of the military authorities in England was meanwhile directed to the question of the adoption of a breech-loading system. In June 1864, a Committee assembled which shortly after reported unanimously that it was desirable to introduce the breech-loading principle without delay. Gunsmiths and manufacturers were invited to send into the Ordnance Committee proposals for the conversion of the existing stock of Enfield rifles, pattern 1853. Some 50 different systems were brought forward and investigated, and the Committee finally selected that of Mr. Jacob Snider, an American. This action was finally adopted in 1867. In it the breech block was hinged on the righthand side of the barrel, and on being opened, gave access to a taper chamber cut in the breech end of the barrel. A projecting stud or spring catch held the block in place. In front of the block was attached a hook extractor, to engage in the projecting rim of the base of the cartridge so as to extract it. The block when open could be drawn back a certain distance, and the empty cartridge thus withdrawn from the chamber was got rid of by turning the rifle on one side and allowing it to fall to the ground. A striker passed diagonally from the hinder end of the breech, where the hammer could strike it, to the centre of the front face of the block, where it impinged upon the cap in the centre of the cartridge. There was little difficulty in fitting this breech action to the existing Enfield rifle. But the accuracy of the shooting was at first much inferior to that of the muzzle-loading arm. This was satisfactorily remedied by Colonel Boxer. He made the walls of the cartridge (attached to the metallic base) of thin coiled brass instead of paper. This effectively checked any escape of gas, and made the cartridge strong and little liable to damage. The bullet had a taper hollow in its base, and a taper plug of wood or (later) of clay was added to insure expansion. It had also a hollow in the forepart, as arranged by Mr. Metford in his explosive bullet of 1864, since this was found to give a distribution of weight more favourable to accuracy. The Snider, when its ammunition had been perfected, made actually better shooting than the muzzle-loading Enfield.

The conversion of the Enfield to a breech-loading system was, however, expressly a temporary expedient, and, in October, 1866, proposals for a new form of rifle were officially asked for, and a Special Committee assembled to deal with the subject. About 120 different arms and 49 descriptions of ammunition were submitted to them, and, after careful examination, followed by trials of certain selected arms, the Committee

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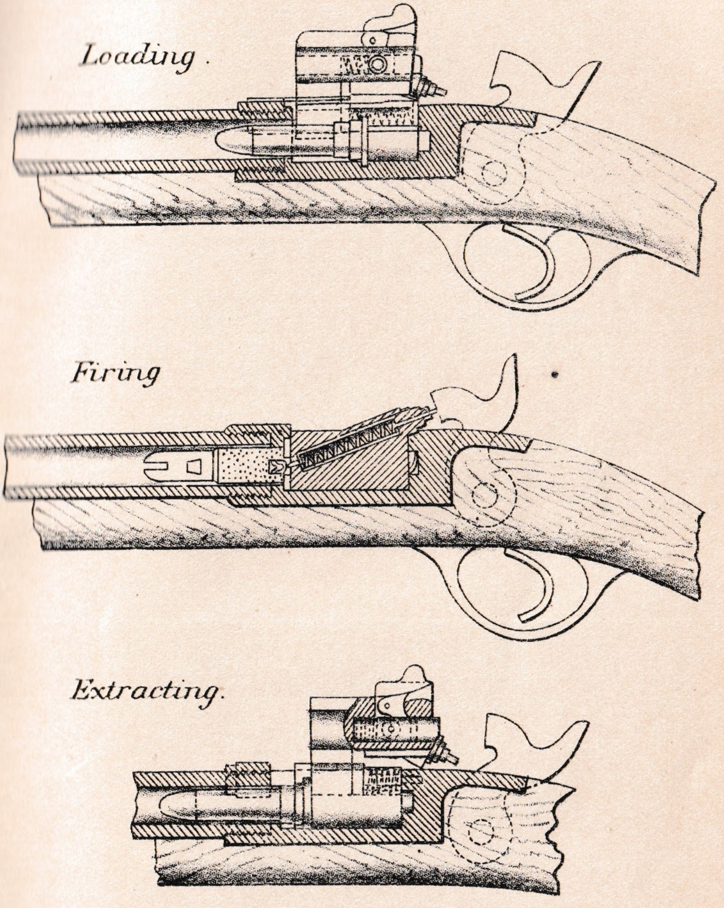
SNIDER.

1866.



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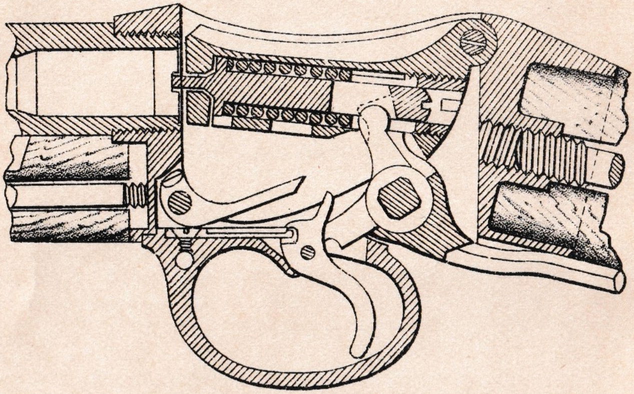
MARTINI BREECH ACTION.

(Closed and Fired.)



MARTINI BREECH ACTION.

(Open)

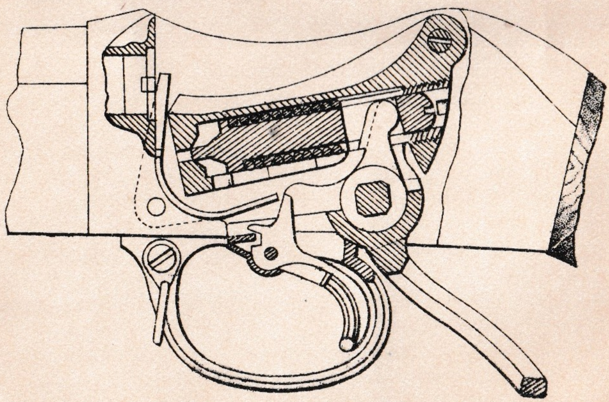


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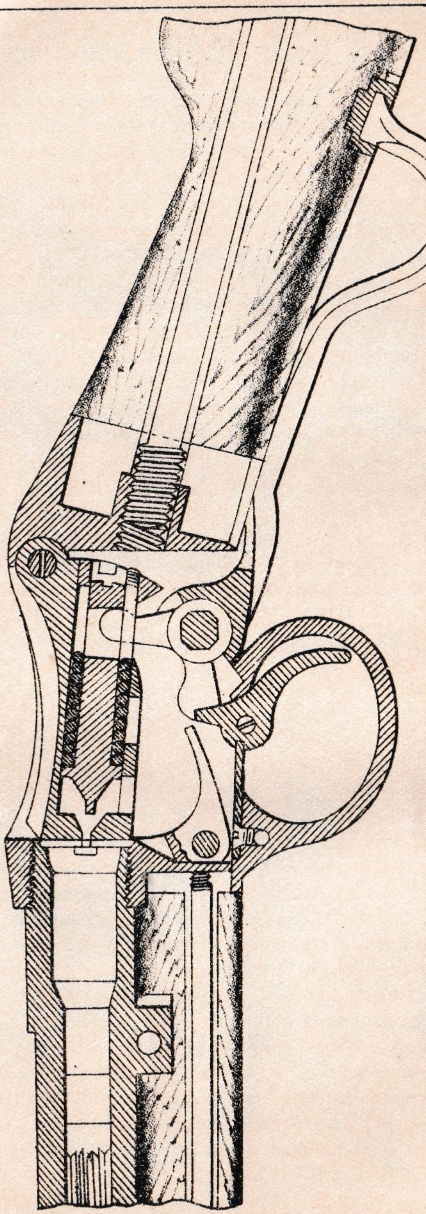
Plate III.

MARTINI ACTION.

(*Cocked ready to Fire.*)



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reported that they had not had before them any arm of sufficient merit to render its adoption into the Service advisable. In December, 1867, the Committee were directed to make more extended investigation, with a view to deciding on a pattern of arm which they could recommend for adoption. They wisely separated the question of calibre and rifling from that of breech action. For the former they decided to hold a competition among the systems which were prominent as giving accurate shooting, in which Messrs. Henry, Lancaster, Metford, Rigby, Westley-Richards, and Whitworth were invited to compete, and also the Enfield and Woolwich factories. All accepted the invitation but Mr. Metford. Certain limits were laid down as to the length, weight, and calibre of the barrel, as to the weight of bullet and powder, and as to the cartridge case. All the competing barrels were to be fitted to the Henry breech action. Meanwhile, the inventors of breech-loading systems were required to submit actions suitable for barrels adapted to the same conditions of cartridge and charge.

Forty-five additional arms were sent in while the Committee were pursuing their inquiry. After prolonged and careful trials, they recommended the breech action submitted by Mr. Martini, as modified at Enfield, in combination with Mr. Henry's barrel, with his bullet of 480 grains, and his system of lubrication with wax in the form of a wad in rear of it. It was decided that the ammunition should be loaded in Boxer cartridge cases of coiled brass. The arm was named the Martini-Henry.

The first experimental issue, in November, 1869, was of 200 rifles, with ammunition, to various stations and to the Navy for trial. Meanwhile, endeavours were made to meet the difficulty caused by the length and slenderness of the cartridge, and trials were made with a bottle-shaped cartridge, a shortened chamber suitably enlarged, and a shortened action. A small trial issue of arms of this description was made in October, 1870.

A new Committee to consider the reports received on the arm was appointed in May, 1870. They went into all the questions involved, and obtained from certain civil engineers and other experts a favourable opinion as to the soundness of the mechanical principles involved in the breech action. They reported that the short action Martini-Henry was admirably adapted for a military arm, and recommended its adoption into the two Services. In April, 1871, it was accordingly adopted.

Further experiments as to the advantage of a bullet weighing only 380 grains, instead of 480 grains, were carried out. It was found, however, that the reduction in weight of ammunition, and the slight increase in velocity and flatness of trajectory at short range, were outbalanced by loss of accuracy, of striking power, and of range. It was thought that, with black powder and a leaden bullet, the bore could not satisfactorily be reduced below ·45.

The following are the particulars of the Martini-Henry Rifle.

Weight without bayonet ..	9 lbs.
„ with bayonet	9 lb. 12 oz.
Length of rifle without bayonet	4 ft. $1\frac{1}{2}$ in.
„ with	5 ft. $11\frac{1}{2}$ in.
„ barrel	33·2 in.
Diameter of bore	·45 in.
Number of grooves	7.
Pitch of spiral	1 turn in 22 in. to right.
Weight of bullet	480 grains.
Diameter of bullet	·45 in.
Weight of powder charge ..	85 grains.
Value of $\frac{w}{d^2}$	·339.
Initial velocity	1,350 ft. per sec.

A fresh Small Arms Committee assembled in 1883 to consider the production of an improved Martini-Henry rifle. They recommended in 1886 the supersession of the bore of ·45-inch by one of ·402-inch, with a leaden bullet of 380 grains, and a charge of 85 grains of black powder, the cartridge case being of solid drawn brass. The rifling they eventually recommended was of 7 grooves, shaped to the segment of a circle, after the pattern of the Metford rifling, which had met with so much success in the rifle competitions at Wimbledon. This shallow grooving, without sharp angles, offered less hold for the fouling than almost any other form of rifling. At the same time, improvements were introduced in the shape of the entry, and the rifle showed great accuracy. Its ballistic qualities were also very good. This rifle was known as the Enfield-Martini, the Martini action being retained with a lever, lengthened to give greater power of extraction. A considerable number of these rifles were made, but there was no actual issue of them to the troops, owing to fresh changes and developments which began to press.

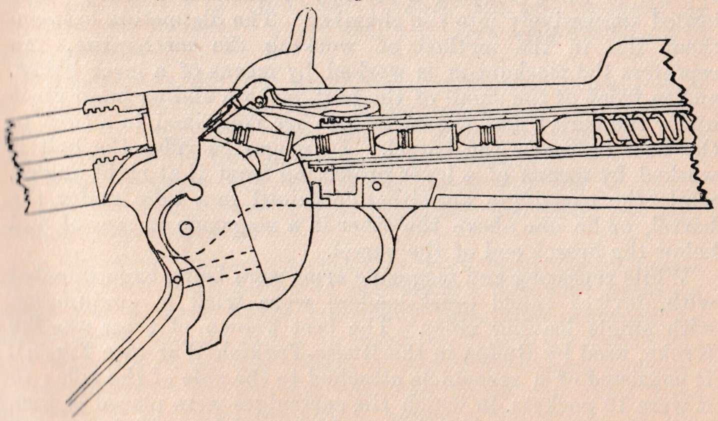
CHAPTER III.

The Introduction of Repeating and Magazine Rifles. Review of the Principal Systems of Magazine Rifles. Automatic Rifles, their Advantages and Defects.

The advantages to be gained by increasing the rapidity with which fire arms could be discharged were recognised very early in the history of small arms. A great advance in this direction was made by the adoption of breech loading weapons, using cartridges containing their own means of ignition. Another marked improvement was effected by carrying in the weapon several charges or cartridges which could be discharged successively by some simple operation of the mechanism, and so save the time occupied in transferring the cartridge from the pouch, or bandolier, to the weapon. This latter idea was first embodied in revolvers which were made as early as the 16th century, but these weapons did not make much headway, until the introduction of metallic cartridges enabled the backward escape of gas and fouling to be overcome. In 1840, Colonel Colt invented a revolving rifle, firing a metallic cartridge, but revolving rifles never proved a success, on account of their inaccuracy, at any but the shortest ranges.

Weapons known as repeaters were the first really successful rifles that contained a reserve of cartridges. In this class of weapon the cartridges lay nose to base, in a tube contained either in the butt or in the fore end. The breech was opened, the empty case was extracted, a fresh cartridge was introduced into the chamber, the breech was closed, and the weapon cocked ready for firing, by lowering and raising a lever pivoted below, and in front of the small of the butt. The earliest successful weapons of this class were the Spencer (see Fig. 3), and the Henry rifles, which were patented in 1860.

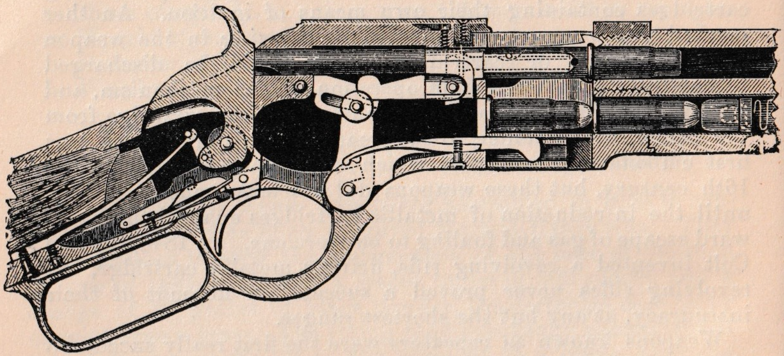
Fig. 3.



Spencer Rifle.

In the former the cartridges were contained in a tube in the butt, and in the latter in a tube under the barrel. Both these weapons were extensively used in the American Civil War. The Winchester repeater, which was an improvement on the Henry, appeared in 1867 (see Fig. 4 from the "Modern Sportsman's Gun and Rifle," by J. H. Walsh).

Fig. 4.



Winchester Repeater.

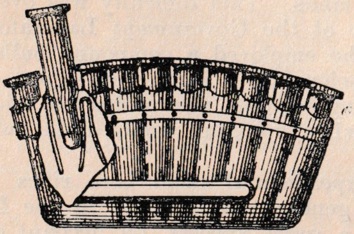
30,000 of them were used by Turkey, in the Russo-Turkish War of 1877–78, with such striking effect, particularly at the siege of Plevna, that the attention of all the great powers was drawn towards the advisability of adopting some form of repeating or magazine rifle.

These two terms "repeating" and "magazine" are both applied to rifles carrying a reserve of cartridges ready to be loaded successively into the chamber. The distinction between them lies in the method of working the mechanism. In repeaters the mechanism is worked by means of a lever below, and in front of the small of the butt, or by a sliding hand piece under the barrel, and the cartridges are contained in a tube in the butt or under the barrel. In magazine rifles the bolt is worked by means of a lever projecting from it at right angles, while the cartridges are either contained in a tube under the barrel, or lie one above the other in a magazine in rear of and below the breech end of the barrel.

While repeating and magazine arms were being experimented with, devices called quick-loaders were tried in conjunction with single loading rifles. The best known of these was the Krnka, used by Russia in the Russo-Turkish War (see Fig. 5). It consisted of a receptacle attached to the side of the rifle; in it were 10 pockets, in which the cartridges were placed in line, base uppermost, so that they could be quickly withdrawn and

placed in the body of the rifle in front of the bolt; the rifle would then be ready for firing on closing the breech.

Fig. 5.



Krnka Quick-loader.

In 1867, the Vetterli magazine system was approved, in principle, in Switzerland, but it was not till 1881, after undergoing many modifications and improvements, that it was finally adopted. This was a bolt rifle of ·41-inch calibre, with a tube magazine in the fore-end holding 11 cartridges, a 12th in the carrier and a 13th in the chamber. The earliest magazine rifle used by any European Power was the Fruhwirth pattern 1870, with which the Austro-Hungarian gendarmerie was armed. This rifle was somewhat similar to the Swiss Vetterli, but had a longer action and shorter barrel, the bore was ·433-inch; 8 cartridges were contained in the tube magazine in the fore-end. The cartridges were lifted by means of a carrier in the form of a scoop in front of the bolt, which, in advancing, pushed them into the chamber. This principle, further developed and perfected, formed the basis of the Kropatschek, the Jarman, the German Mauser and Commission of 1884, and of the Lebel rifles.

In 1878, the French Marine Infantry were armed with the Kropatschek ·433-inch bore, which held 7 cartridges in the tube magazine. In 1881, the Jarman rifle was adopted by Norway and Sweden. These last two rifles were not issued in large numbers.

Germany was the first great power to provide its army with a magazine rifle. In 1884, it converted the 1871 pattern Mauser of ·433-inch bore into a magazine rifle, holding 8 cartridges in the tube magazine in the fore-end.

All the magazine rifles mentioned above, with the exception of the Lebel, are over ·4-inch bore, and are what are now termed large bore rifles.

In the early eighties experiments were being conducted on the Continent, with a view to producing a rifle with a greater range, and a much flatter trajectory, than were possessed by the weapons then in use. In order to flatten the trajectory, and so minimise the bad effects of errors in judging distance, it was necessary to increase the velocity, at the same time maintaining a proper proportion between the weight of the bullet and the area of its cross-section.

It was found that the long small bore bullets required a quick twist of rifling to keep them steady, but the lead bullets first tried would not follow this quick rifling, and were driven out across the lands. This difficulty was overcome by Major Rubin, Director of the Government Laboratory of Thun, in Switzerland, who employed a compound bullet, consisting of a lead core, enclosed in a copper envelope. This latter was sufficiently strong to resist the torsion and friction to which it was subjected when fired, and enabled the bullet to follow the rifling.

The early experimental small bore rifles were used with black powder, generally compressed in the form of a pellet. This was not a great success, on account of the moderate velocity obtained, and the amount of smoke and fouling produced.

The important invention of a smokeless rifle powder in 1885, by M. Vieille, a young chemist of the French Government Powder Factory, was a leading factor in making the modern small bore a practical success. Powders of this class give a higher velocity, with a lower pressure, than black powder, they leave very little residue in the barrel, and are practically smokeless, which is an important tactical advantage, as it enables the soldier, even when firing rapidly, to see his enemy without disclosing his position.

The French immediately took steps to make practical use of this invention. General Boulanger, who was then Minister of War, gave orders for the designs of a small bore rifle to be prepared within three months. The Lebel rifle of 1886 was the result; it has a tube magazine containing 8 cartridges, and the bore is ·315-inch. This rifle, of which a full description is given in the next chapter (see page 55), was the first of the modern small bore rifles.

In this year, 1886, Austria adopted a Mannlicher rifle, ·433 bore, with a straight-pull bolt, which latter, instead of being partially rotated by the bolt lever during the first movement of opening, unlocked itself, on the bolt lever being drawn straight to the rear (see page 34). This rifle was the firs adopted by any European nation embodying Lee's box magazine. This invention was patented in 1879 and 1882, and consisted of a box in rear of, and below the entrance to the chamber, containing the cartridges lying in a horizontal position one above the other. A platform, actuated by a spring, pushed the cartridges upwards, so that when the bolt was pushed forward, it struck the base of the top cartridge and pushed it into the chamber. Another important improvement introduced with this rifle, was the principle of multiple loading, which was affected by a sheet steel clip containing 5 cartridges. The clip full of cartridges was pressed into the magazine, and retained by a catch until the cartridges were expended, when it fell out through an opening in the bottom of the magazine. In 1888 these rifles were converted to ·315 bore, firing black

powder cartridges, and in 1890, on the introduction of smokeless powder, the sights were re-graduated.

Germany was the first power to adopt a small-bore rifle, that was a multiple loader, firing smokeless powder. A Mannlicher rifle, of ·311 bore, with a magazine loaded by a clip containing five rimless cartridges, was adopted in 1888. It was the most up-to-date rifle of any in use at that time.

In this country the steps that led to the introduction of a small bore magazine rifle were as follows :—

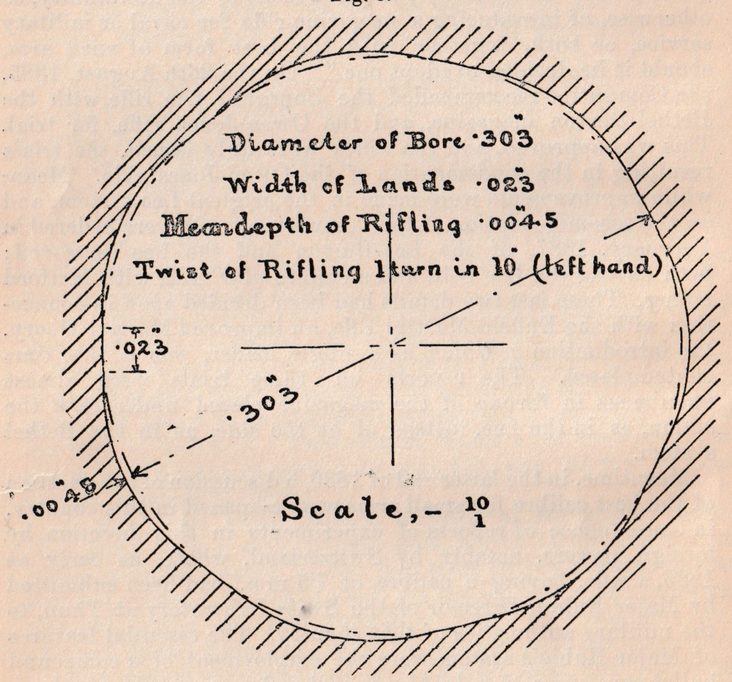
In February, 1883, a Committee was appointed to work out details in connection with a new single loading rifle, which was a modification of the Martini-Henry. This Committee was also instructed—"To take up the question as to the desirability, or otherwise, of introducing a magazine rifle for naval or military service, or both, together with the best form of such arm, should it be decided to adopt one." On the 26th August, 1885, the Committee recommended the improved Lee rifle with the Bethel-Burton magazine, and the Owen-Jones rifle, for trial. This was approved, and the rifles were duly issued, the trials resulting in the condemnation of the Owen-Jones rifle. Meanwhile improvements were made in the original Lee system, and on the recommendation of the Committee, trials were ordered in February, 1887, of the Lee-Burton and the Lee improved; both having the Lee bolt, and a calibre of 0″·402, with Metford rifling. These last two details had been decided upon in connection with the Enfield-Martini rifle, an improved Martini-Henry, the introduction of which, as a single loader, was at that time contemplated. The reports on these trials were almost unanimous in favour of the magazine placed underneath the action, as in the Lee, instead of at the side, as in the Bethel system.

Meantime, in the latter end of 1886, a discussion of the question of the best calibre for small arms was re-opened in this country, in consequence of reports of experiments in this direction by foreign powers, notably by Switzerland, where, as early as 1883, a rifle, having a calibre of 7·5 mm., had been submitted by Major Rubin, Director of the Swiss Laboratory at Thun, to the military authorities of that country. The essential features of Major Rubin's system were the employment of a compound bullet consisting of a lead core enclosed in a copper envelope, and the use of a compressed charge of black powder.

In January, 1887, the Small Arms Committee was directed to undertake experiments in regard to this point, and a Rubin rifle with a calibre of 0″·3, and Rubin ammunition, was used for the trials. As a result of their experiments the Committee recommended, in June, 1887, the small calibre for adoption into the British Service; and in January, 1888, a pattern of ·303 inch calibre rifle, rifled on the Metford system (see Fig. 6), and with the improved Lee bolt and magazine, was approved to govern the supply of 350 rifles for issue for extended trials by the troops, throughout the British Empire. These rifles were sent

out in July and August, 1888, and the reports subsequently received were perfectly satisfactory as regards the efficiency of the rifle. Cartridges loaded with a compressed pellet of 70 grains of black powder, giving a velocity of 1,850 feet per second were first used with these rifles. Cordite cartridges were introduced in April, 1892. Minor alterations which had suggested themselves in the interval having been made, the rifle was finally approved in December, 1888, sealed as the Lee-Metford Magazine Rifle, Mark I, and its manufacture immediately commenced. This rifle was afterwards converted to the Mark I*, the pattern of which was sealed 19/1/92.

Fig. 6.

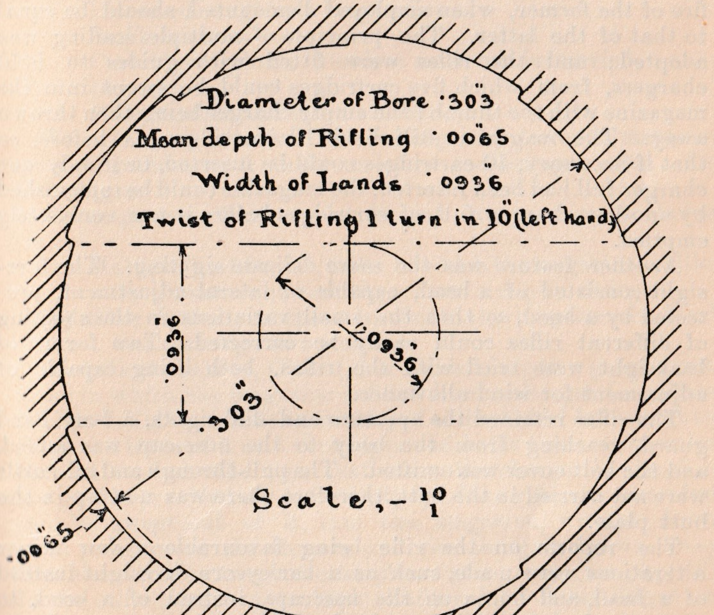


Metford Rifling.

In July, 1890, a Committee was appointed at the War Office to consider and discuss the reports on the Mark I rifle received from various sources, and to submit for approval any minor alterations which, by the light of these reports, might be considered necessary. The Committee was also instructed to consider the advisability of substituting a magazine holding 10 instead of 8 cartridges as in the Mark I rifle. The result of their labours was the production of Mark II pattern, with a magazine holding 10 cartridges in two columns, a much simplified bolt, and many minor improvements; this, after

thorough trial in the hands of the troops, was finally approved in December, 1891. This rifle was followed in 1895 by the Mark II*, which was similar to the Mark II, but was provided with a safety catch on the rear end of the bolt, which, when turned up, locked the striker, and prevented the bolt being opened, either in the cocked, or fired position. In November, 1895, the Lee-Enfield rifle was introduced : this rifle is similar in all respects to the L.-M. Mark II* with the exception of the form of the rifling, and the sighting.

Fig. 7.



Enfield Rifling.

It was found from experience, that the erosion produce by cordite, allowed but a comparatively short life to the shallow-grooved Metford rifling with its narrow lands ; hence the introduction of the Enfield rifling, (see Fig. 7), which has five grooves, the bottoms of which are concentric with the bore ; the depth is about ·002 of an inch greater than that of the Metford grooves, while the width of the lands is increased from ·023″ to ·0936″. The L.-E. Mark I* differs from the above rifle only in the omission of the clearing rod, and its groove in the fore-end.

In 1894 a L.-M. carbine was introduced, followed in 1896 by a L.-E. carbine. These carbines are similar to the L.-M. II* and L.-E. rifles except that the barrels are 9½ inches shorter, and are covered by a long wooden handguard; the foresights are protected by wings on the nose-cap, and the long range sights are omitted.

In January, 1900, a Committee was appointed to report upon matters connected with small arms. In 1901 they recommended that 1,000 experimental short L.-E. rifles should be issued to the troops for trial. These rifles were issued in June, 1902; they were 5 inches shorter than the L.-E. rifle, and were suitable for use by both Cavalry and Infantry; thus the accuracy of the fire of the former, when employed dismounted, should be equal to that of the latter. The principle of multiple loading was adopted; and the rifles were fitted with guides to hold chargers, from which five cartridges could be swept into the magazine with the thumb; the empty charger being then thrown away. The magazine still held 10 cartridges as before, so that if necessary, 10 cartridges could be inserted, or if only one charger full had been inserted, the magazine could be replenished by another charger full of cartridges before it was completely emptied.

Another feature was the more delicate sighting. The foresight consisted of a bead, capable of lateral adjustment, protected by a hood, so that the small variations in the shooting of different rifles could easily be corrected. Two forms of backsight were tried with the rifles, both being capable of adjustment for wind allowance.

The rifles retained the aperture and dial sights, a long hand guard, reaching from the body to the nose-cap was added, and the bolt cover was omitted. The pull-through and oil bottle were not carried in the butt, therefore there was no trap in the butt plate.

The reports on the rifle being favourable a few minor alterations were made, such as a barleycorn foresight instead of a bead, and horns on the nosecaps, instead of a hood, to protect the foresight, and the rifle was approved on 23rd December, 1902, as rifle, short, magazine, Lee-Enfield, Mark I. The Mark II pattern was a similar rifle converted from long rifles, M.L.M., Mark II*, and M.L.E.

Rifle, short, M.L.E., Mark III, was approved 26th January, 1907, see Chapter IV, page 67. The chief differences between it and Mark I were that the design of the backsight was improved, and a U notch provided instead of a V. The foresight consisted of a blade instead of a barleycorn, and a bridge charger guide replaced the sliding charger guide on the bolthead and the fixed charger guide on the body.

The Mark IV pattern is a similar rifle converted from long rifles, M.L.M., Marks II and II*, and M.L.E.

A pattern to guide the conversion of the M.L.M., Marks II, II*, and M.L.E. rifles to charger loading for the Territorial Army

was approved on 18th July, 1907. The conversion consisted in providing an adjustable blade foresight with protector and a windgauge backsight, the windgauge of which was traversed by a screw. A bridge charger guide was fitted, identical with that of the short M.L.E., Mark III rifle.

The above gives an outline of the introduction of magazine arms, by this and other countries.

Their advantages, when combined with a small bore and smokeless powder, in comparison with large bore single breech loaders, are as follows:—

Rapidity of fire.
Flatness of trajectory.
Increased range and penetration.
Smokelessness.
Cartridges lighter, therefore more can be carried.
Less recoil.
Rifle handier and more accurate.

We will now consider the principal systems of magazine arms together with their relative advantages and disadvantages.

All magazine rifles may be divided into two great classes, viz.:—

(A) Multiple loaders, *i.e.*, those in which the magazine is filled by a number of cartridges from a clip or charger.

(B) Slow loaders, or those in which the magazine is filled, one cartridge at a time.

As indicated above, Class (A) is divided into two groups, viz., those in which the magazine is filled from a charger (see Plates LXI to LXIII), consisting usually of a sheet steel holder, which grips the bases of 5 or 6 cartridges and holds them more or less parallel to each other; so that when the charger is placed in the guides provided for it in the body of the rifle, the cartridges can be swept out of it, into the magazine, with a downward pressure of the thumb, and the charger thrown away. The Mauser rifles are good examples of this group (see page 42). In the other group of multiple loaders, 5 or 6 cartridges are held together more or less parallel to each other by a sheet steel clip (see Plates LXIV and LXV), which covers the rear part of the cartridges for about half their length. The clip complete is pressed down into the magazine and is held there by a catch, which engages a projection on the back of it. (See Plate XLI, Italian rifle.) When the cartridges are expended, the clip falls out of the magazine through a hole in the bottom of the latter. A clip with any cartridges still in it, may be ejected by releasing the catch which retains it. The Dutch and Roumanian Mannlicher rifles are good examples of this group (see page 71).

The cartridges in rifles of the above two groups are pressed upwards by the magazine spring acting on a lever or platform so that the top cartridge is in position to be pushed into the chamber on closing the bolt.

Rifles in Class B may be divided into three groups with the following types of magazines :—

1. Tube magazines.
2. Box magazines, adapted for loading with one cartridge at a time.
3. Magazines with controlled platforms.

In rifles now in use, of group (1), the magazine consists of a tube in the fore-end, below the barrel. The cartridges are inserted into it one at a time, from the rear end, through the body of the rifle. They lie in a line, nose to base, and are pushed to the rear by a spiral spring and plunger. They are raised up in front of the bolt by a pivoted carrier, operated by the bolt. The Lebel rifle is a good type of this group (see page 55).

In group (2) the Lee-Metford and Lee-Enfield are the only rifles of note. They resemble the charger loaders, in being provided with a box magazine; but the body is not provided with guides to hold a charger. The ammunition is packed singly, so that only one cartridge at a time can be loaded into the magazine.

Group (3) consists of rifles, with magazines in which the cartridges lie side by side. The platform, that presses the column of cartridges into position in front of the bolt, can be drawn back for loading, so that loose cartridges can be more quickly dropped into the vacant space than is possible in the case of the Lee-Enfield, where the opposition of the magazine spring has to be overcome each time a cartridge is inserted. The Krag-Jorgensen, Ross rifle, and the Lee-Enfield with Harris magazine, are types of this group. In the former (see page 51) the magazine lies horizontally under the body of the rifle. It is provided with a hinged door on the right, on opening which, the platform is drawn back, and the magazine spring compressed. In rifles fitted with the Harris magazine, a small lever, forming a thumbpiece, is pivoted on the left of the fore-end, where the left hand grips the rifle. On depressing this lever, the platform of the magazine is lowered, and loose cartridges can be quickly dropped into the latter. In the Ross rifle adopted by Canada, the platform is attached to a lever pivoted in the fore-end under the backsight. A finger-piece on this lever projects between the right side of the barrel and the fore-end, so that when the finger-piece is pressed down, the magazine platform is lowered, and cartridges can easily be inserted into the magazine.

The advantages and disadvantages of the above magazine systems are briefly as follows.

Class "A," multiple loaders compared with slow loaders.

Advantages. The magazine can be quickly loaded. The correct number of cartridges to fill the magazine are kept together, correctly arranged, ready for rapid loading. A clip, or a charger, is more easily handled than single cartridges,

particularly when the hands are numbed with cold, and they are less liable to be lost from the pouch or bandolier.

Disadvantages. Clips or chargers add weight and take up more room in packing. If they become rusty, gritty, or dented, they may cause a jam in charging magazines or feeding up. The partially emptied magazine of a rifle, loaded by clips, cannot be filled up without removing the clip and cartridges in it and inserting a full clip.

Class "B," slow loaders compared with multiple loaders.

Advantages. The magazine can be easily replenished with one or two cartridges when it has been partly emptied. The single cartridges can be packed in a smaller space. There are no clips or chargers to add weight.

Disadvantages. The process of filling the magazines is slower. In rapid firing, after the magazine has been emptied, the rate of fire is about the same as that of a single loading rifle, with the exception of class (3). Single cartridges are apt to get lost from the pouch or bandolier.

Class "A," comparing charger with clip loading:—

Clips require an opening for them to pass through in the bottom of the magazine; this lets in dirt, especially when firing over a parapet, or when firing lying down. They are larger and more liable to be dented than chargers. With clips the cartridges are in a single column, therefore the magazines are deeper than those used with chargers containing the same number of cartridges. The magazine can be rather more easily loaded with a clip, than with the cartridges out of a charger; and when required the magazine can be easily unloaded. With a charger, extra pressure can be applied with the thumb, to sweep the cartridges out of it, if extra friction is set up by rust or dirt, but with a clip the strength of the magazine spring cannot be temporarily increased to overcome any abnormal resistance. With charger loading a partly emptied magazine can be filled up with single cartridges if required.

Class "B," comparing one group with another.

In rifles with tube magazines, the balance of the arm is altered as the line of cartridges passes down the tube. This is very detrimental to snap shooting. Rifles with controlled platforms, group (3), partly overcome the slowness caused by filling the magazines with loose cartridges; but to get the best results from them, considerable dexterity is required to pour a stream of cartridges correctly into the magazine. The Lee-Metford or Lee-Enfield magazine is decidedly superior to a tube magazine, as it is simpler, and the balance of the arm is not altered as the magazine is emptied. One advantage, possessed by the Krag Jorgensen, is that the magazine can be filled during intervals in firing with the bolt closed and the rifle loaded ready to fire.

The conditions a magazine rifle should fulfil are:—

1. *Durability.* The rifle should be simple, compact, and strong; free from risk of derangement due to accident, long

wear and tear, rough usage on active service, exposure to wet or sand, or fouling from long continued firing. It should be capable of being easily cleaned and inspected, and if, after long use, any part does break down, it should be easily and cheaply repairable. The mechanism should be capable of being stripped without the use of tools.

2. *Rapidity of fire.* Filling the magazine, and loading the cartridges into the chamber, should be quick, easy, and certain operations. The sights should be simple and not liable to shift during firing; they should be capable of being quickly set, easily seen and accurately aligned.

3. *Accuracy.* The graduations should give the correct elevation for the distances marked; the foresight should be placed so as to give the true direction; and the points of impact, on the target, of a group of shots fired at the same mark should be close together.

4. *Lightness and handiness.* A light rifle can be easily carried by the soldier, and, in rapid firing, raising it frequently to the shoulder does not cause so much fatigue as it would in the case of a heavy rifle; consequently, in prolonged firing, or in snap shooting, better results should be obtained with a light rifle. For deliberate shooting a fairly heavy rifle is easier to hold steady. Lightness is governed by the strength of the barrel and breech closing mechanism necessary to resist the explosion of the charge and the tendency to vibrate excessively; by the solidity required to stand rough usage; by the length of the rifle; and by the weight necessary to check the recoil. With regard to the length of a rifle, a long barrel gives increased velocity, it enables the sights to be further apart, which increases the accuracy with which aim can be taken, and it gives a longer reach in bayonet fighting. A short barrel is handier, and vibrates less than a long one of equal thickness; this latter point tends to improve the consistency of the shooting. The body is kept as short as possible for the sake of compactness, and the length of a rifle is altered by varying the length of the barrel. The length of the butt cannot be varied much, as the distance from the butt plate to the trigger depends on the length of the soldier's arm. In the British service butts of three lengths are now issued, so that the soldier may be properly fitted, with a view to improving his snap shooting, in which the balance of the rifle is very important. The centre of gravity should be a little behind the point where the fore-end is gripped by the left hand, so that, when the soldier throws his rifle up to his shoulder, it may point at the required object. If the centre of gravity is too far back, the rifle, when quickly brought to the shoulder, tends to point above the object, and *vice versa*.

5. *Good ballistics.* The initial velocity should be high, the proportion between weight and area of cross section of the bullet should lie between proper limits, and the shape of the bullet should be well adapted for overcoming the resistance of the air, so that the trajectory may be flat.

For the qualities a cartridge should possess, see page 189.

We have seen how the rapidity of fire of rifles has been accelerated; firstly, with muzzle loaders by using bullets which set up into the grooves on firing; secondly, by combining the charge into a cartridge containing its own means of ignition, and inserting it into the barrel from the breech end as in the Snider rifle. Thirdly, by combining the operations of opening the breech, extracting the empty case, closing the breech and cocking the weapon into two simple movements as in the Martini-Henry. Fourthly, by having a magazine in the rifle, such as is used in the Lee-Enfield, so that the time occupied in taking the cartridge from the pouch and putting it into the rifle, is saved. Fifthly, by employing a charger such as is used with the short Lee-Enfield rifles, by which means the time occupied in filling the magazine is considerably reduced.

All these improvements have resulted in an extremely rapid rate of fire being obtained. Inventors are now engaged in endeavouring to effect a further improvement, by utilising some of the force developed by the explosion of the charge, to open the breech and reload the rifle automatically; all that will then be required of the soldier will be to aim, press the trigger for each shot, and recharge the magazine when it is empty.

The advantages to be gained by automatic loading are :—

1. Extreme rapidity of fire, for the rifle can be fired as fast as the trigger can be pressed. There is no need to loosen the grip of the right hand on the small of the butt, in order to work the bolt. The rifle need not be taken down from the shoulder between the shots, therefore the firer's attention is not distracted from the object, and his muscles are not tired by raising and lowering the rifle.

2. The recoil of the rifle is reduced in weapons operated by the recoil, for the backward motion of the barrel and bolt is gradually absorbed by one or more spiral springs, so that the recoil as felt by the shoulder, partakes more of the nature of a push than of a blow.

Automatic rifles are either—

(*a*) Self-firing rifles.

(*b*) Self-loading rifles.

Self-firing rifles continue to fire as long as the trigger is pressed, or until the magazine or belt is empty. Only heavy rifles weighing about 16 or 20 lbs., such as the Hotchkiss Portative, can be so employed, for a light rifle would move too much, and the shooting would be wild. These rifles are virtually portable machine guns.

Self-loading rifles fire one shot for each pressure of the trigger, they reload themselves, and are ready to fire on again pressing the trigger.

Automatic rifles are operated by either of the following means :—

1. By using the force of recoil.

2. By drilling a small hole in the barrel, and using some of

the highly compressed gas, generated by the explosion of the charge, to operate the mechanism by means of a piston and cylinder.

These forces of the recoil, and of the gas pressure, are respectively utilised to unlock and drive back the breech bolts of automatic rifles on the above two systems. At the same time they compress one or more strong spiral springs, the reaction of which force forward and lock the breech bolts, leaving the rifles ready for firing.

Up to the present this idea has been applied more to pistols than to rifles, and with the former the recoil system is used; the difficulties are less than in the case of rifles, on account of the charge and the moving parts being lighter, and the problem being on a smaller scale.

The two principles of loading and extracting automatically, by utilising either the force of recoil or the gas pressure, have been successfully applied to machine guns; the force of recoil being used in the Maxim gun, while the Hotchkiss and Colt machine guns are operated by gas pressure. The problem of automatic reloading is also easier in the case of machine guns than with weapons carried by the soldier, as the size, disposition, and weight of the mechanism are less restricted.

The commonest form of recoil-operated rifles are those in which the barrel and body are given a short recoil, about $\frac{3}{4}$-inch, during which the bolt is unlocked, the bolt completing its rearward course by means of the momentum it has acquired. In this type the action can be kept compact, but the recoil is not absorbed to so great an extent as in the long recoil type. This latter type is not finding favour on account of the great length of the action.

In all automatic rifles it is very necessary to exclude dirt and dust as much as possible, as the extra friction they set up seriously interferes with the automatic action.

Experience with automatic rifles in considerable numbers is not at present available, but the following are the chief advantages and defects of the two systems.

Recoil-operated Rifles.

Advantages. The recoil is reduced, particularly with the long recoil type, and the mechanism can be kept compact in the body of the rifle.

Disadvantages. The force of recoil is not great with small bore cartridges, especially with such a small bore as the ·256, therefore, there is not much reserve of force to overcome extra friction caused by rust or dirt. This is particularly the case in rifles in which the bolt has to depend upon the momentum it has acquired at the instant at which it is unlocked from the barrel, to compress the spring which drives it forward again and locks it. In some types of recoil-operated rifles, means are provided to transfer part of the momentum of the barrel to the

bolt by means of a lever, or system of levers, operated by the barrel. Usually the magazine does not move with the barrel, and steps have to be taken to ensure that the bolt pushes the cartridges out of the magazine only when the barrel is in the correct position to receive them. As the barrel is sliding back along the stock as the bullet leaves the muzzle, any alteration in the amount of recoil through variation in friction would affect the jump and the accuracy of shooting; the bayonet could not be fixed to the barrel for this reason. With recoil operated rifles the action is generally longer than with gas operated rifles.

Gas-operated Rifles.

Advantages. Great power is available, therefore strong returning springs can be used, which tend to make the automatic working of the rifle more certain. The barrel is fixed, therefore it does not move relatively to the magazine and is not sliding back along the stock as the bullet leaves the muzzle. The recoil is decidedly less than with ordinary magazine rifles of the same weight.

Disadvantages. The gas cylinder and piston are liable to be fouled by the metallic fouling swept along by the gas. These parts and the gas ports cannot generally be cleaned without stripping the arm. The fore-end has to be considerably cut away to receive the gas cylinder and connecting rod. Gas operated weapons are generally more liable to get their components burred or broken than recoil-operated rifles, on account of the greater force available to work the mechanism.

An automatic rifle should fulfil the same conditions as a magazine rifle, see p. 29; and besides being capable of use as an automatic rifle, it should also be designed so that it can be used as an ordinary magazine rifle, in case its automatic action fails through rust or dirt. The great desideratum in an automatic rifle is certainty of action, both when the mechanism is clean and dirty, and this quality has not yet been attained. The disadvantage of their requiring greater care than magazine rifles will have to be faced. This should not prove insurmountable, as a similar disadvantage, differing only in degree, was accepted on the introduction of breechloading arms and magazine rifles, and has been overcome by teaching the soldier to take greater care of his weapon.

Silencer.

A silencer to lessen the sound of the report when a rifle is fired, and also to lessen the shock of discharge, is being experimented with by the United States, but has not yet been officially adopted.

CHAPTER IV.

DESCRIPTION OF THE SMALL-BORE RIFLE OF EACH POWER.

AUSTRIA-HUNGARY.

Rifle, Pattern 1888–90.

The 11 mm. Mannlicher magazine rifle, pattern 1886, was superseded in 1888 by an arm practically identical with it in every respect, except that the calibre was reduced to 8 mm., and the backsight graduations extended to a longer range. The backsight was again regraduated in 1890, upon the introduction of a smokeless explosive.

Barrel. The barrel, which screws into the body, tapers slightly. The foresight block and backsight bed are formed on it out of the solid.

Sights. The foresight is of the barleycorn pattern, and is dovetailed into its block at right angles to the axis of the barrel; this arrangement allows of adjustment for any lateral error which may exist in individual rifles.

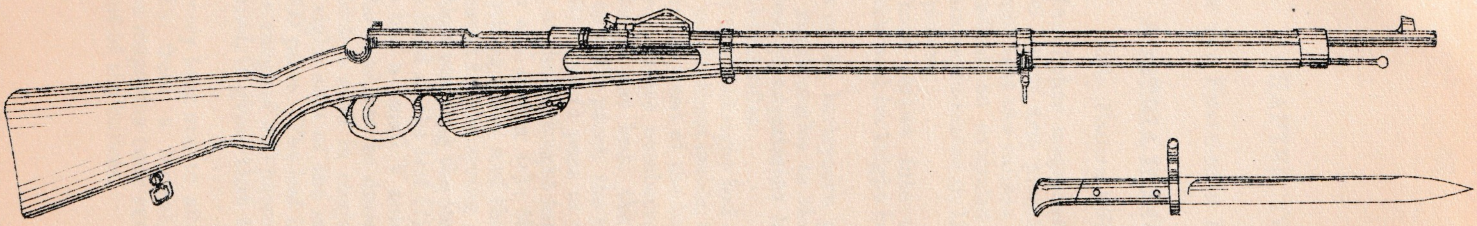
The sides (2) of the backsight bed stand up from the barrel, and have grooves cut in them inside, the grooves radiating from the axis pin (3) in the front of the bed, on which the sight leaf pivots. These grooves are numbered on the faces of the rear slopes of the sides of the bed, the left-hand figures are for ranges from 600 to 1,800 paces, the right-hand ones for ranges from 2,000 to 3,000 paces (1 pace = ·75 metre = 29·53 inches). On the underside of the backsight leaf, J, are secured two bars (*q.q.*) actuated by a V spring (*r*); they have projecting finger pieces (*s.s.*) for working them, and their outer edges are bevelled off. They are pressed by the spring (*r*) into the grooves in the sides of the bed, thus enabling the leaf to be set at any required graduation. The head of the leaf (*t*), is inclined upwards and broadens out; it has a small V notch cut in it. A slide (*u*), dovetailed into the head, can be drawn out to the right; it also has a V notch which is used in conjunction with a small cone (4) fixed in the right side of the middle band, K, for ranges from 2,000 to 3,000 paces. The leaf in the lowest position gives the elevation for a range of 300 paces, but in the bottom groove, which is not figured, it gives that for 500 paces; this is the fixed sight.

Body. The body is a very long one to allow for the special locking arrangement. In front a tongue (5) projects downward against which the magazine body rests, and which serves as a guide for the point of the bullets.

Plate IV.

AUSTRIA HUNGARY 1888-90.

To face page 35.



2316.

Weller & Graham. Ltd. Litho. London.

AUSTRIA HUNGARY 1888 - 90.

Plate V.

To face page 35.

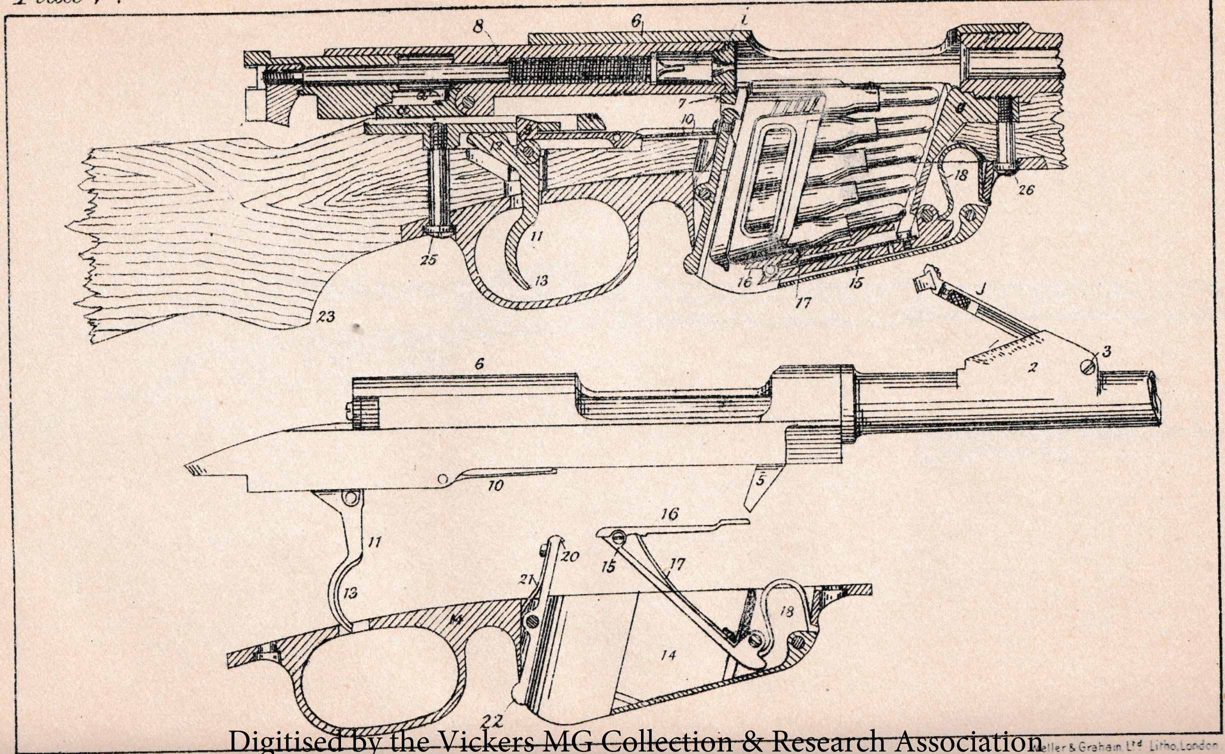


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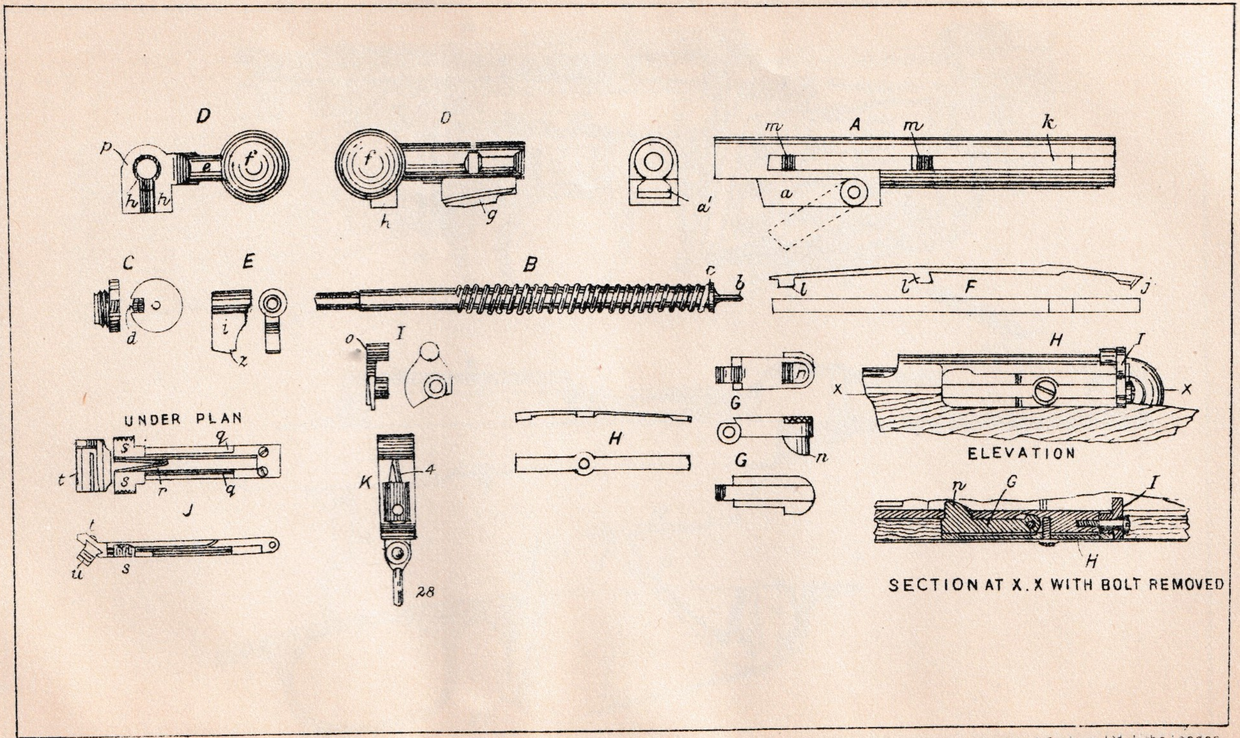
Plate VI.

AUSTRIA HUNGARY. 1888-90

To face page 35.



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The back portion is a hollow cylinder (6), with a groove for the extractor spring in the right side; on the left side is a projection for the retaining and safety bolts with their spring. A hole is cut in the underneath of the body, for the hinged block of the bolt, in rear of the magazine way, but is separated from the latter by a short bridge of metal (7). The rear end of the body is in the form of a tang with sides, and has a groove cut in it for the cocking stud to travel in.

Bolt. The bolt proper, A, is a long cylinder, bored out from the front for the striker and mainspring, the back part of the hole being reduced in diameter to form a seating (8) for the mainspring. It is prolonged to the rear and has a slot cut in this part underneath, the sides being vertical. In front of this slot is hinged a block (*a*) with a dovetailed recess (a^1) cut in it from the rear.

Mainspring. The mainspring, of ·152 wire, has 26 coils, and is set to a length of 3·83″.

Striker. The striker, B, has a short point (*b*) and a collar (*c*) against which the mainspring bears. It is inserted from the front of the bolt, which is closed by a plug C, screwed in; the plug has a gate (*d*) cut in it for the extractor, and by this means it is locked.

Lever cylinder. A short hollow cylinder, D, works in the rear portion of the bolt. On its right side it has a short lever (*e*), terminating in a large knob (*f*). In front, underneath, is a solid piece (*g*), flanged so as to slide in and out of the dovetailed recess (a^1) of the hinged block (*a*) of the bolt, the flanges sloping upwards from back to front. In rear the cylinder has two horns (*h*, *h*) which project downwards and travel between the upright sides of the tang of the body.

Cocking piece. The firing pin screws into the cocking piece, E, which works inside the lever cylinder, the cocking stud (*i*) itself moving between the two horns *h*, *h*.

Extractor. The extractor, F, is a long, slightly curved spring, terminating in a claw (*j*). It is secured in the slot (*k*) cut for it in the right side of the bolt, by its two studs (*l*, *l*) which dovetail into the holes (*m*, *m*) cut for them in the bolt cylinder.

Retaining bolt. The retaining bolt, G, is pivoted in the left side of the body, and has a tooth (*n*) of rounded section projecting into the bolt way. A groove for this tooth is cut in the left side of the bolt cylinder, but does not extend quite to its front end. The retaining and safety bolts are both actuated by the same spring, H.

Safety bolt. The safety bolt, I, is a flat plate with thumb piece (*o*), pivoted in the left side of the body. The plate when turned, from the left, through an angle of 90°, enters a recess (*p*) cut for it in the rear end of the lever cylinder, and so prevents the latter being drawn back. When at full cock the plate comes in front of the left side of the cocking piece, and so prevents the striker moving forward; at the same time, owing to a slope on its face, it withdraws the striker to the rear from contact with

the sear. If the safety bolt is not completely turned over, when the action is at full cock, and if then the trigger is accidentally pressed, the cocking stud will move forward until held by the sear engaging in the notch (z). If it were not for this notch, which has been recently introduced, the cocking stud would, under the above-mentioned circumstances, pass over the sear, and only be held back by the safety bolt, so that should the latter be taken off, the firing pin would fly forward and fire the cartridge.

Sear. The sear (9) projects upwards through a hole cut for it in the tang of the body; it is part of a long flat spring (10) attached to the underside of the body.

Trigger. The trigger (11) is secured to the underneath of the sear; it is a bell-crank lever, one end (12) bearing against the body, the other end (13) projecting downwards into the trigger-guard. It has a double pull-off. The first pull is a sliding movement, on completion of which the leverage shifts, a slight check is felt, and on further pressure the bent parts smartly, and the striker is released. This arrangement gives a light final pull, and is generally to be found in continental arms. There is no half cock, nor can the striker be placed at full cock without opening and reclosing the action.

Action of the bolt mechanism. The action is opened by a straight backward pull on the lever, the lever cylinder, D, first coming to the rear, bringing the cocking piece, E, and the striker, B, with it, and partly compressing the mainspring. The flanged piece (g) at the same time raises the hinged block (a) from its seating, and the latter then bearing against the former, prevents it and the striker moving forward, and so keeps the mainspring compressed. The whole bolt is then drawn back until brought up by the retaining bolt, G. The empty case is withdrawn by the extractor, and is pressed by it over to the left. The base of the cartridge comes in contact with the left side of the bridge of metal (7) in the body and is ejected to the right.

There is no cam action for giving primary extraction, but the extraction is aided by the hammering action which results from the lever cylinder starting before the bolt cylinder and extractor.

In closing, the cocking stud (i) is caught by the sear nose (9), and is held, while the bolt itself moves forward over the striker and mainspring, completing the compression of the latter, at the same time the flanged piece (g) forces the hinged block (a) to the front, and then into its recess in the body, and so locks the action. The face of the bolt, as it moves forward, catches the upper edge of the rim of the top cartridge in the clip, and before the cartridge is free from the clip, the bullet has entered the chamber and forms a guide to lead the cartridge forward. When the clip ceases to hold the base of the cartridge, the extractor catches it and forces it against the hollowed left side of the body along which it slides into the chamber.

The claw of the extractor enters a recess cut for it in the

chamber, and engages in front of the base rim of the cartridge. The striker is released by pressing the trigger as already described.

The magazine and trigger-guard (14) form one component. The magazine contains two levers (15, 16), hinged together with a flat spring (17) between them, the lower lever is pivoted in the front of the magazine, and is actuated by a spring (18) of ribbon steel. The rim cartridges, 5 in number, are contained in a clip (see Plate LXIV) stamped out of sheet steel, which, owing to its rhomboid form, can only be inserted one way up. It is inserted from above, and as it is forced into the magazine, it pushes the levers to the bottom. The clip is held in its place by a catch (20) attached to the back of the magazine, and actuated by a small flat steel spring (21). The action of the springs 17 and 18 on the levers force the cartridges up out of the clip, which, when empty, falls out through a hole, cut for the purpose, in the bottom of the magazine. As long as the clip contains any cartridges, it is, on releasing the catch (20) by pressing on the thumb-piece (22), forced up with its contents out of the action. **Magazine and clip**

There is no cut-off, and the rifle cannot therefore be used as a single loader when there are cartridges in the magazine, nor can the magazine be replenished by the introduction of single cartridges. The top lever (16), however, serves as a platform for single loading when the magazine is empty.

The stock is in one piece, with pistol grip (23) and fore-end grooves. The body, stock, and magazine with trigger guard, are held together by two screws (25, 26) passing up into the body from underneath, one in rear of the trigger guard and one in front of the magazine. **Stock.**

The upper band has a projection on its left side for the sword bayonet, and a short rod screwed in underneath the barrel to facilitate piling arms. The middle band, K, carries a sling swivel (28), and the long range foresight (4) already described. These two bands are secured by screwed pins, passing through the fore-end from side to side. The rear band is secured by a screwed pin and nut. A second sling swivel is screwed into the butt. The butt plate is of steel and is secured by two screws; it has no trap. **Band and swivels, &c.**

A handguard of canvas, lined with felt, has been adopted owing to the heating of the barrel by the smokeless explosive. It is secured in front of the backsight bed. **Handguard.**

There is no cleaning rod on the rifle itself, but every soldier carries in his kit a rod in three pieces, which can be screwed together. **Cleaning rod.**

The sword bayonet is attached to the left side of the rifle in the usual way. The blade has a broad back, but near the point it is double edged. The pommel and cross piece are of polished steel. The scabbard is of steel, oil blacked, with a hook for attaching it to the frog. **Sword bayonet.**

Rifle, Pattern 1895.

This rifle, like its predecessor, is a Mannlicher, but it is on the average $1\frac{3}{4}$ lbs. lighter; this gain is due to the barrel being lighter though fully as long, and to the body bolt and magazine being considerably shorter. The bolt is secured by lugs on the bolt head engaging in recesses just in rear of the barrel, instead of by a hinged block under the back part of the bolt.

Barrel. The barrel which screws into the body is light and tapers slightly from the reinforce over the chamber to the muzzle.

Sights. The foresight block forms part of a sleeve which is fixed to the barrel by means of a cross pin. The barleycorn foresight is dovetailed into this block at right angles to the axis of the barrel.

The backsight bed is bored out so that the barrel passes through it; bed and barrel are fixed together by means of a cross pin. The leaf, A, is pivoted to the rear end of the bed; it has a short leaf (*a*) at right angles to it in which the fixed sight, V, for 500 paces is cut. The leaf proper is graduated on the left side from 600 to 2,600 paces, the even hundreds only being marked; the right side of the leaf is blank; 300 paces is obtained by raising the leaf and pushing up the slide, a V being cut in the bottom of the leaf. The back of the leaf is cut away at the edges at (*b*, *b*). The right side of the slide is made with two projections, which serve as guides to the stud (*d*). This stud has a small tooth on it which locks into the small notches, cut for it on the inside of the right groove (*b*), for every 200 paces graduation. The stud (*d*) is disengaged from the notches by pressing the finger piece (*c*) which is connected to the stud by means of a plate passing across the face of the slide. To keep the stud (*d*) up to its work a small spiral spring, within the finger piece (*c*), presses the latter away from the slide.

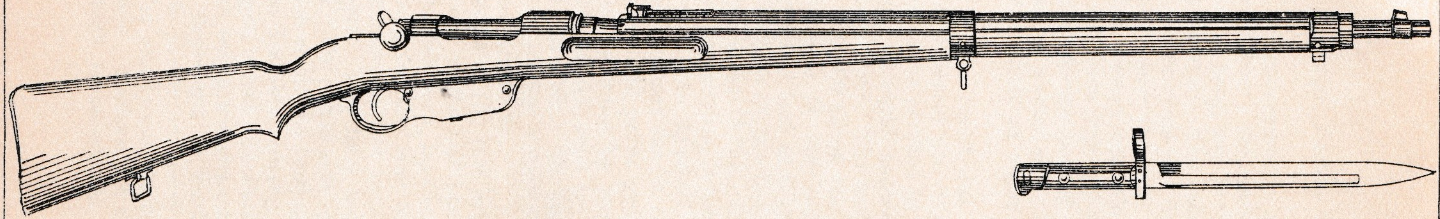
Body. The body is recessed at (3) just in rear of the barrel to form seatings for the lugs on the bolt-head. Two grooves (3_a), one on either side of the bolt way, lead into these recesses. A long slot is cut in the tang for the sear and ejector, and in rear of this again is a transverse slot into which project the horns (*w*, *w*) on the trigger. The tang has the usual groove for the cocking piece stud. On either side of this groove is an under-cut groove, in which work the feathers (e_1, e_1) on the underside of the bolt. These feathers, coming in contact with the horns (*w*, *w*) on the trigger, arrest the backward motion of the bolt, and prevent it from being withdrawn from the body until the horns (*w*, *w*) are depressed by pushing forward the trigger. The groove (3_a) is partly cut away on the right side of the body to allow of the empty case being ejected, and to facilitate loading the magazine. Underneath the front part of the body is a projection which transfers the shock of recoil from the

Retaining arrangement.

AUSTRIA HUNGARY 1895

Plate VII.

To face page 39.



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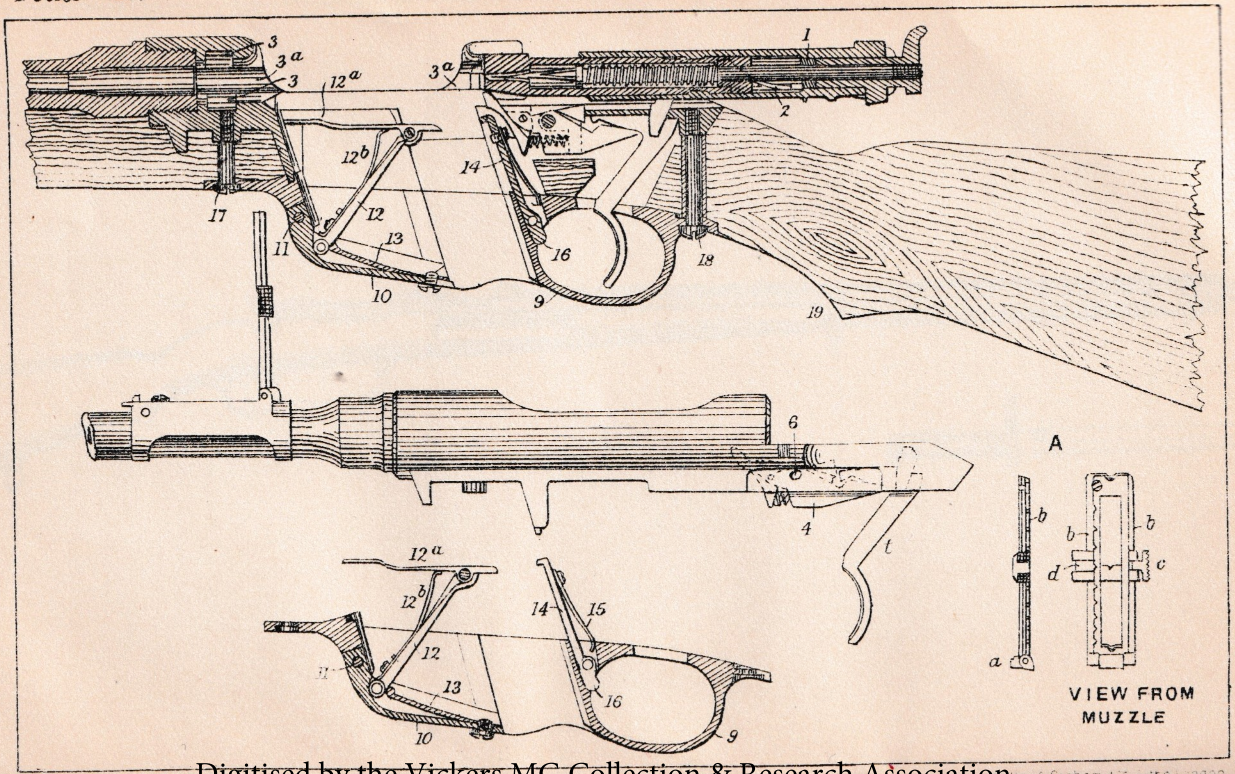
AUSTRIA HUNGARY 1895

Plate VIII.

To face page 39.



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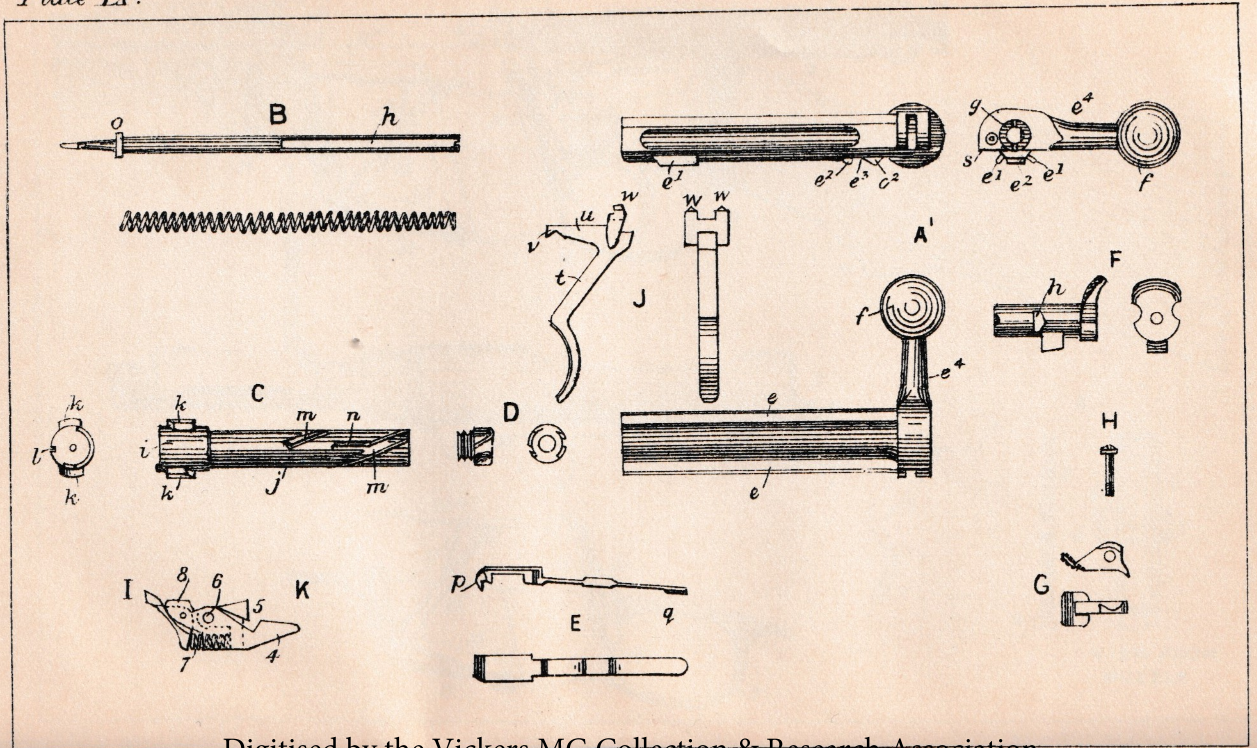
AUSTRIA HUNGARY 1895

Plate IX.

To face page 39.



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barrel and body to the stock. A similar but larger projection, just in rear, forms the prolongation of the front of the magazine.

The bolt proper, A^1, is a hollow cylinder with ribs (e, e) on either side, which work in the grooves (3_a), in the body. In front, underneath, are the two feathers (e_1, e_1) already mentioned, and in rear is a small safety projection (e_2), with a groove (e_3) in it for the ejector to rest in when the bolt is closed. The back end is reinforced and carries the lever (e_4) at right angles on the right side, the lever terminating in a knob (f). The underneath of the reinforce is cut away for the stud of the cocking piece. The recess for the cocking piece is separated from that for the tail of the bolt-head by a collar (1) secured by a screw, the point (g) of which projects into the firing pin hole and, bearing against a flat (h) on the firing pin (B), prevents the latter from turning. The locking and safety bolt is pivoted in the left side of the reinforce. Inside the middle portion of the bolt are two helical feathers (2) which work in corresponding grooves (m, m), in the tail of the bolt-head, and give to the latter a movement of rotation in opening and closing the bolt. A groove is cut on the inside of the right rib for the extractor. Bolt.

The bolt-head, C, consists of the head proper (i), which projects beyond the face of the bolt cylinder, and the tail (j) which enters the cylinder. The bolt-head has cam-shaped locking lugs (k, k), on either side, which enter the recesses (3, 3) of the body by way of the cam-shaped grooves, and support the bolt-head in the firing position. A groove (l) is cut in the head for the ejector. The rear end of the tail has two external helical grooves (m, m) in which work the feathers (2) in the inside of the bolt cylinder. The helical grooves have each a small groove (n) leading out of them in the direction of the length of the bolt, one to the front, and one to the rear. The groove to the front is on the top of the tail, that to the rear is on the right side when the bolt is opened. Bolt-head.

The bolt-head contains the mainspring of ·04 wire with 34 coils, coiled to a length of 4·9 inches, and the striker, B. The rear end of the bolt-head tail is closed by a screw plug, D, against which the mainspring bears, the striker, B, passing out through the plug. The other end of the mainspring bears against a collar (o) on the striker. The extractor, E, is a long flat spring which lies in the right rib of the bolt cylinder. The portion which projects fits over the right locking lug (k) and terminates in a broad claw (p). The other extremity has a small nib (q), on its underside, which engages in the two longitudinal grooves (n, n), in the tail of the bolt-head, above mentioned. When the action is closed, the nib is engaged in the longitudinal groove on the top of the bolt-head tail; when the bolt is drawn back, the nib rises out of this groove and when the bolt-head has turned a quarter of the circle from right to left falls into the other groove. Mainspring. Striker. Extractor.

The right lug is then embraced by the head of the extractor and the extractor is drawn back by the bolt. The claw engages the top cartridge in the magazine immediately it is pushed forward by the bolt in advancing, and holds it in all the backward and forward motions of the bolt, thus rendering double loading impossible.

Cocking piece.

The cocking piece, F, screws on to the end of the striker and works in the rear end of the bolt cylinder. In its left side is a groove (*r*) in which the locking bolt, G, engages, when it is employed to lock the action with the spring eased. At full cock the locking bolt, when used as a safety bolt, is interposed between the front face of the cocking piece and the rear face of the bolt cylinder; the tooth of the bolt is cam-shaped and when pushed into position, forces back the cocking stud from engagement with the sear. It is secured to the reinforce of the bolt at (*s*) by the screw H. The action is precisely the same as in the Austrian rifle, pattern 1888/90.

Sear.

The sear, K, consists of two components, the body (4) and the bent (5); they are both pivoted on the same pin (6) which passes through the action body. The bent (5) fits in a slot in the body (4).

Ejector.

The ejector, I, is pivoted to the front of the sear body. Its bottom end is pressed forward by a small spiral spring (7), the other end of which presses the sear and sear bent backwards. The upper end of the ejector is slightly depressed by the bolt; the spring (7) is partly compressed, and tends to keep the sear and sear bent (5) up to their work.

Trigger.

The trigger, J, is in the form of a bell crank lever, the long arm (*t*), projecting downwards through the trigger guard, the short arm (*u*) terminating in a hook (*v*) which engages the rear of the sear. At the angle is the crosspiece with the two horns (*w*, *w*) which project into the boltway and prevent the withdrawal of the bolt as already described. The trigger is not pivoted to the body in any way, but is supported in its groove by the sear.

When the trigger is pressed, the bent of the sear is depressed, releasing the cocking stud and allowing the striker to fly forward; at the same time the front of the sear body (8) is raised into the boltway behind the safety projection (e_2) on the back end of the underside of the bolt, preventing any backward motion of the latter whilst the arm is being fired. Further, as the bolt is pushed forward, this safety projection (e_2) sliding over the projecting front portion (8) of the sear, prevents the latter rising, and consequently prevents the bent of the sear from being lowered, by pressing the trigger, until the bolt is completely closed.

Action of the bolt mechanism.

The bolt, like that of the rifle, pattern 1888/90, is actuated by a straight backwards-and-forwards pull and push. When the lever is pulled to the rear, the bolt cylinder cannot revolve owing to the ribs on it working in the grooves of the body, and the feathers, in the undercut grooves in the tang. The

bolt-head, on the other hand, cannot come to the rear until the locking lugs have been disengaged from their recesses in the body, and this is effected by the turning motion given to the tail of the bolt-head by the helical feathers in the inside of the bolt cylinder, working in the bolt-head tail. Primary extraction is given by the cam shape of the ends of the grooves in the body in which the locking lugs work. The first motion of the bolt to the rear partly compresses the mainspring. As soon as the locking lugs are disengaged from the body they are in prolongation of the ribs in the bolt cylinder, and the whole bolt can then be drawn to the rear, until brought up by the feathers (e_1, e_1), on the underside of the bolt, coming in contact with the horns (w, w) of the trigger. There is a small slot (l) in the bolt-head into which the ejector enters, and, catching the cartridge rim, ejects the case.

In closing the bolt the above movements are reversed, the sear bent engaging the stud of the cocking piece and completing the compression of the mainspring. The action can be cocked without opening and closing the bolt by pulling back the cocking piece.

Magazine. The magazine holds 5 cartridges which are loaded into it in a clip of the same pattern as that used for the pattern 1888 rifle. The magazine and guard (9) are in one piece. The rear of the magazine is open underneath to allow the empty clip to fall through. The bottom of the magazine is closed in front by a trough (10) secured by a screw (11). The elevator (12) is pivoted in the front end of the trough, and is actuated by a strong flat spring (13) attached by a screw to the rear end of the trough.

The platform (12_a) is pivoted to the top end of the elevator, and is actuated by a flat spring (12_b) which is screwed and pinned to the elevator.

In the back end of the magazine is pivoted a catch (14) for the clip, actuated by a flat spring (15), the end of the catch terminating in a stud (16) which projects into the trigger guard. A full or partially emptied clip can be removed, when the bolt is drawn back, by pressing the stud (16), when the clips and cartridges will spring up out of the magazine.

The magazine and guard are secured to the body by two screws, one (17) passing up in front into the body, the second (18) passing up in rear into the tang.

Stock and furniture. The stock is in a single piece with pistol grip (19). The lower band is secured by a screw passing through it and the fore-end. It is open at the bottom and is tightened by a screw on which is pivoted a sling swivel. The upper band is secured by a screw passing through it and the fore-end. On the left is a projection carrying a short rod with a knob at the end, as in the pattern 1888/90. There is no nose-cap. Grooves are cut for the thumb and fingers of the left hand. The butt carries a steel butt plate secured by two screws, and a plate with a sling swivel is screwed on to its underside. A long handguard

extends from the upper band to the rear end of the backsight bed. A small plate screwed on to the latter secures the end of the handguard.

Bayonet. The bayonet and scabbard are similar to those for the pattern 1888/90 rifle, but are slightly smaller.

For weights and dimensions see Table IV, Appendix.

Cavalry Carbine Pattern, 1890.

Sights. This carbine is similar to the rifle pattern, 1895, but is shorter.

The sights are of similar pattern to those on the rifle pattern, 1895, except that the foresight block is soldered to the barrel, and the backsight leaf is only graduated up to 2,200 paces.

Stock. The stock has two bands which pass round the fore-end and handguard, they are each secured by a transverse screw through the fore-end and band. The front band carries a bar underneath for the attachment of the pommel of the sword bayonet, and on the left is a piling rod as in the rifle. The lower band is divided underneath and carries a sling swivel. The other sling swivel is pivoted to a plate screwed to the underside of the butt.

The handguard extends from the upper band to the rear of the backsight, where it is held down by a small plate, screwed to the backsight bed.

Weight..	7 lbs. 2 ozs.
Total length	3 ft. $3\frac{1}{2}$ ins.
Length of barrel	1 ft. $7\frac{1}{2}$ ins.

It fires the same ammunition as the rifle, the muzzle velocity being 1900 f.s.

BELGIUM	Mauser,	7·65	mm.	adopted	1889.
GERMANY	,,	7·9	,,	,,	1898.
SPAIN	,,	7·0	,,	,,	1892.
BOER	,,	,,	,,	,,	1892.
TURKEY	,,	7·65	,,	,,	1890.

In the plates of the Mauser rifles the longitudinal section of the Belgian and Spanish Mausers are shown in Plate XV.

The parts common to most of the patterns are shown in Plates XV and XVI.

The parts special to the Belgian and German Mausers are shown in Plates XVII and XVIII.

Plate I. AUSTRIA HUNGARY. MANNLICHER CARBINE 1890.

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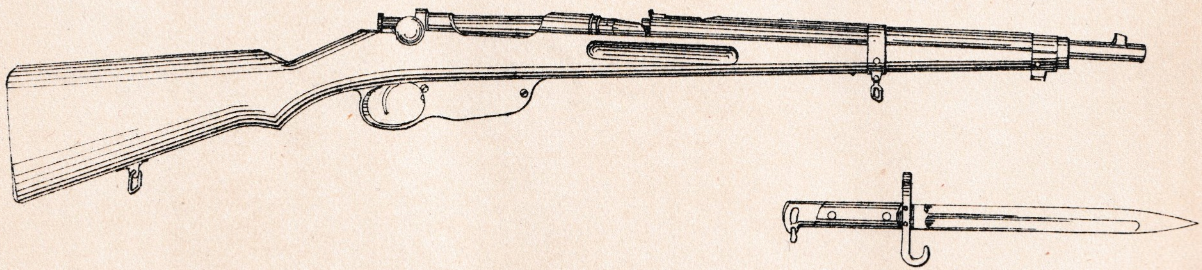

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BELGIUM MAUSER RIFLE 1889.

Plate XI.

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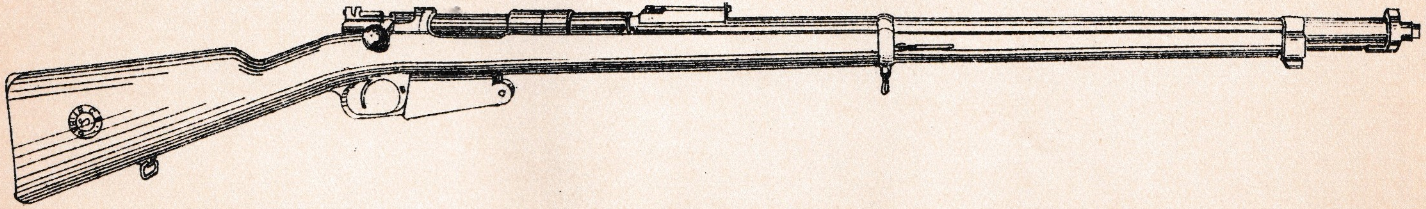

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Plate XII.

GERMANY MAUSER RIFLE 1898.

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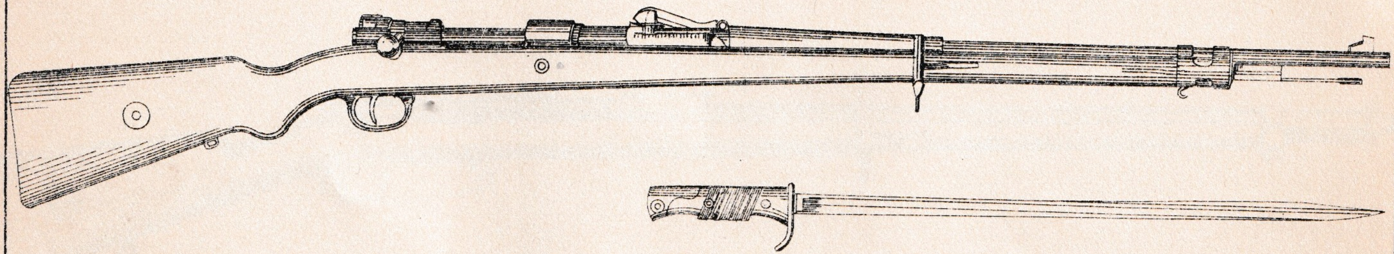

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SPAIN. MAUSER RIFLE, 1892.

Plate XIII.

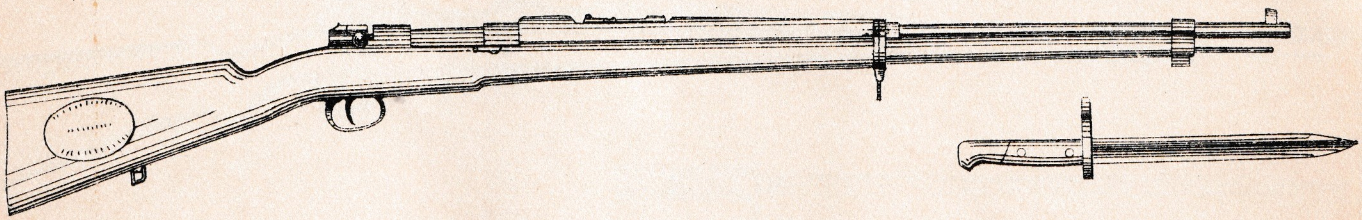

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Plate XIV.

TURKEY. MAUSER RIFLE 1890.

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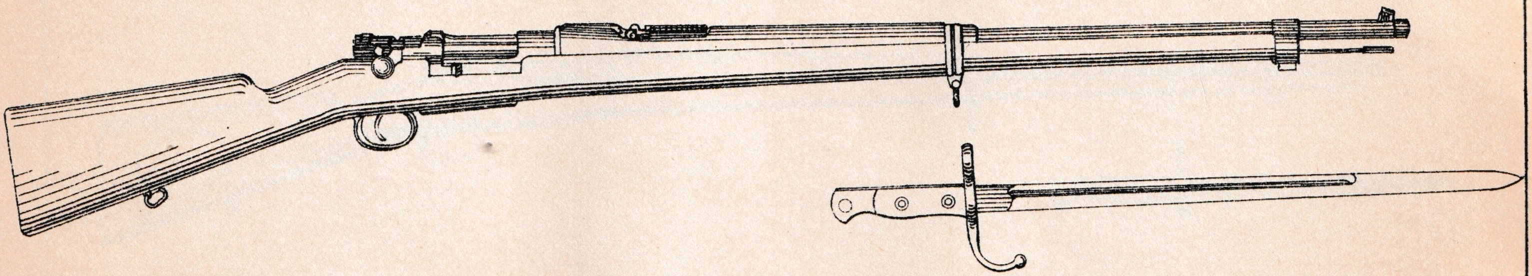

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Plate XV.

MAUSER RIFLES

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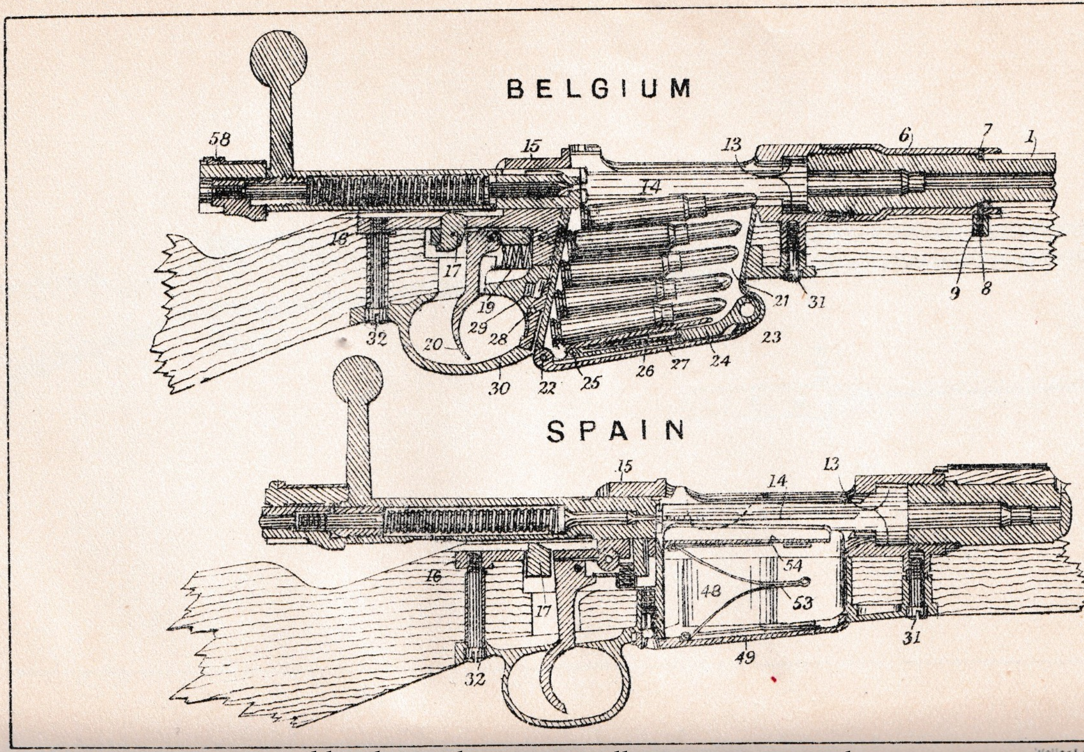

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Plate XVI.

MAUSER RIFLES.

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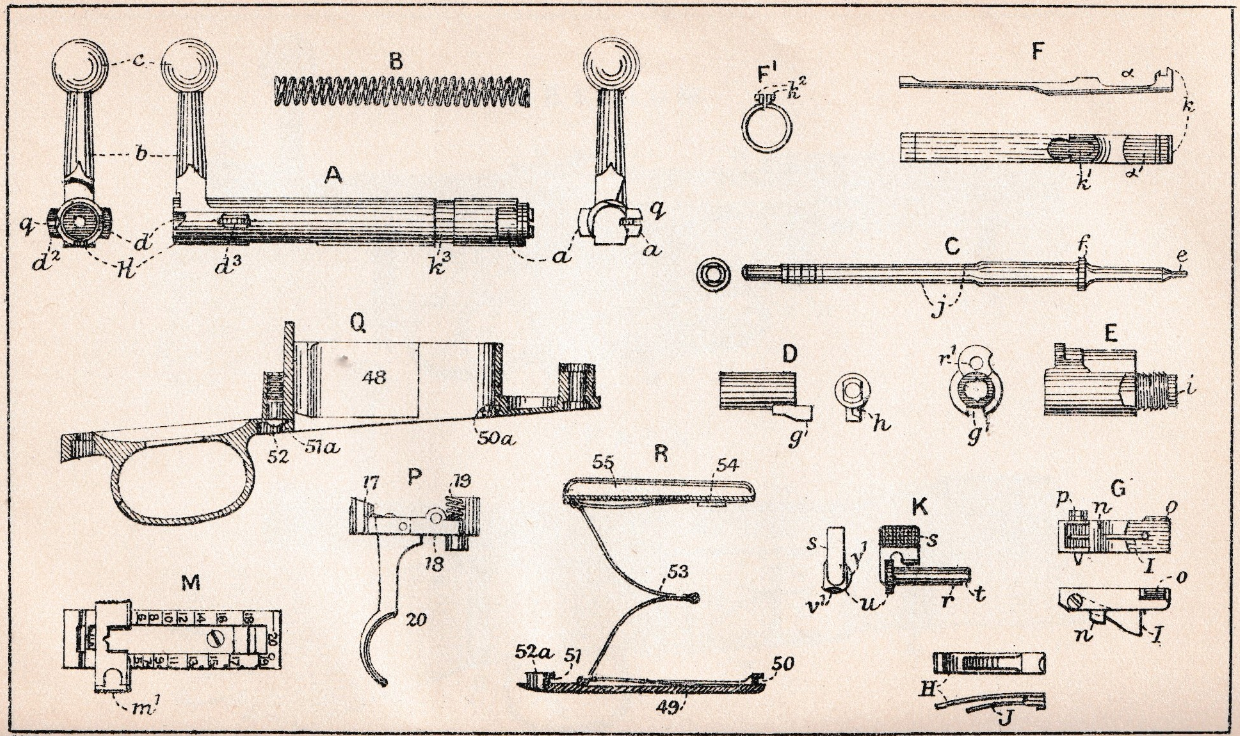

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Plate XVII.

MAUSER RIFLES

To face page 43.

BELGIUM (SPECIAL)

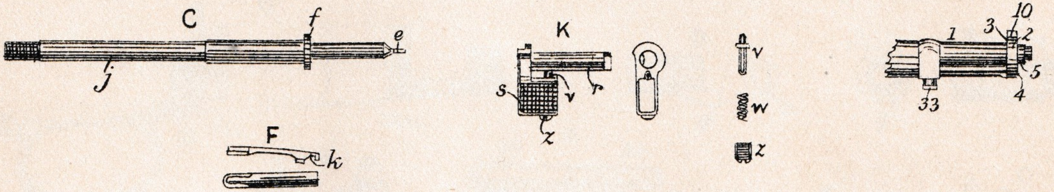

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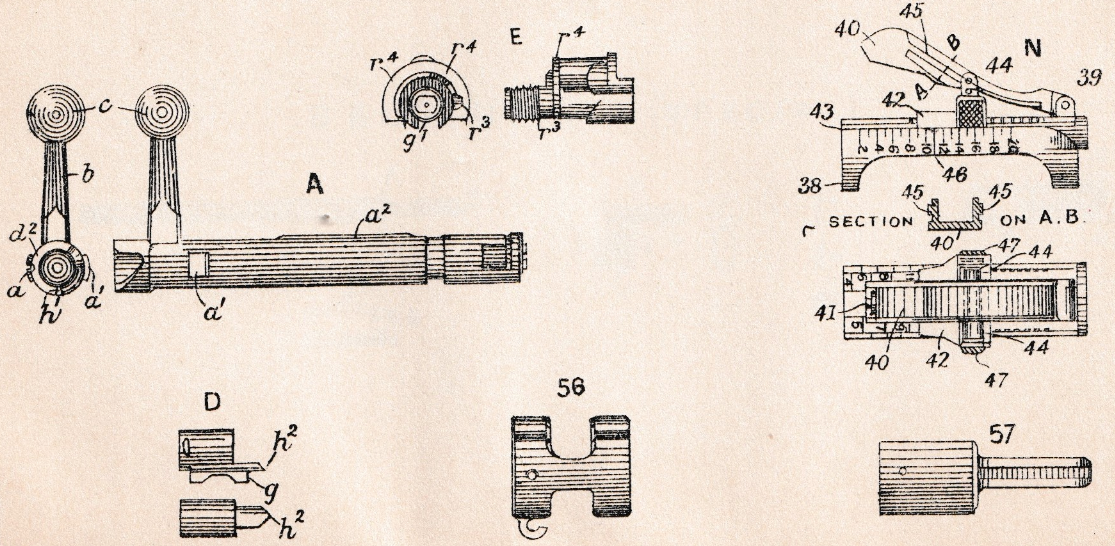
Plate XVIII.

To face page 43.

SPECIAL TO GERMAN MAUSER



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The Spanish and Boer Mausers being almost identical, the former only will be alluded to in the following description, except when pointing out the small differences.

Barrel. The barrel of the Belgian Mauser is thin, and externally is left rough from the turning tool. The diameter of the breech end is increased about 1 in. in front of the chamber, and again about the centre of the chamber. The breech end is screwed into the body. The sights are attached to the barrel casing, which is described later.

In the German, Spanish and Turkish patterns the barrel is polished and browned externally, and is turned down in steps, the portions between them tapering slightly. In these three patterns the sights are attached to the barrel.

Barrel casing. The barrel of the Belgian Mauser is covered by a thin tube of solid drawn mild steel (1), on to which, near the muzzle, is shrunk a ring (2), carrying the foresight block (3), and the rod holder (4); this ring ends in a collar (5), fitting close to the muzzle, for the ring of the sword bayonet cross-bar. A thicker cylinder (6) is secured by screws (7) at one end to the rear of the casing, at the other to the body; a pin (8) projects downwards from it, into a bushed hole (9) in the stock. For the advantages and disadvantages of barrel casings see Chapter V.

Sights. The foresight in all patterns is a barleycorn (10) dovetailed into its block at right angles to the axis of the barrel. The block, in all the patterns except the Belgian, is carried on a thin collar, which is pinned and soldered to the barrel.

The backsight of the Belgian Mauser is brazed on to the casing, just in front of the first reinforce. The bed has ramps cut into steps. The sight is of similar pattern to that of the L.-E. rifle, but the V-notches in slide and cap are smaller.

The backsight of the Spanish and Turkish models is formed with a thin tube underneath, which encircles the barrel, and is screwed and soldered to it. At right angles to the leaf M, at the rear end, is a small projection with a notch for 400 metres in the Spanish, and 250 metres in the Turkish rifle. The face of the leaf is graduated from 400 to 2,000 metres. On the right side of the slide is pivoted a catch (*m*), which is controlled by a small spiral spring. On pressing down the outer end of the catch, a small tooth on its inner end is raised out of slots, which are cut, on the right edge of the leaf, opposite each 100 metres graduation. When this tooth is raised, the slide is free to move along the leaf.

The German backsight, N, is of novel construction. The bed consists of a tube (38) soldered and screwed to the barrel. This tube has a flat top, at the front end of which are the ears (39), forming the joint for the leaf (40) of ⊔ section, which is provided with a single V (41) at the rear end. A slide (42) travels along the bed, being held to it by the grooves (43). This slide is provided with an arm (44) on either side of the leaf. On the inner sides of these arms are two studs, which

fit, one above the other below, the ribs (45) on the outer sides of the leaf. As the slide is moved forward, these studs raise the leaf and thus regulate the elevation of the V. The graduations are marked on the top surface of the bed, even numbers on the right, odd numbers on the left. The even numbers are also marked on both sides of the bed. To use these graduations on the sides of the bed, pointers (46) on the slide are provided. Roughened finger pieces (47) are fitted to the slide; these are provided with teeth, which engage in notches on the bed; the tooth actuated by the finger piece on the right side engages in the notches on the left of the bed, and *vice versâ*. On pressing the finger pieces together, the slide is free to move. The notches are arranged to admit of the slide being set for intervals of 50 metres.

Body. The body is screwed on to the breech end of the barrel in the usual manner. On either side of the bolt way a groove (14) is cut in which work the lugs on the bolt, and the extractor. The groove on the right side is partly cut away to allow of the cartridges being ejected to the right. At the front end of these grooves are the recesses (13) for the locking lugs of the bolt. The rear part of the body, through which the bolt moves, forms a complete cylinder (15), and behind this it is prolonged into a tang (16) with a groove in it for the cocking stud. The body is cut out underneath for the magazine, and an opening is cut in the tang for the tooth of the sear (17), which projects into the groove for the cocking stud. In the Spanish and Turkish patterns another opening is cut, just behind the magazine way, for a tooth on the front end of the sear. This tooth rises as the trigger is pressed and engages in the slot (d_3) in the bolt. In the German pattern a cross groove is cut, just behind the magazine way, for the lug (a_1) of the bolt; and the left side of the body is cut away, as shown by dotted lines in the section of the Spanish rifle, to give clearance for the thumb, so as to enable the cartridges to be quickly swept out of the charger into the magazine without fear of injuring the end of the thumb. In the Turkish pattern there is a small horizontal cut-off, somewhat similar to the Lee-Metford pattern, pivoted in the right side of the body, and controlled by a flat spring having a tooth, which engages in suitable notches in the cut-off.

Bolt. The bolt A is of strong and simple construction, without any movable bolt-head. It can be stripped without the use of tools. The locking lugs (a, a) are opposite one another at the front end.

On the German bolt is an extra lug (a_1) engaging in a recess in the cylindrical part at the rear end of the body. The face is recessed to receive the base of the rimless cartridge; the lever (b) is straight, and stands out at right angles from the rear end of the right side of the bolt. At the end is a round knob (c).

At the back end of the bolt is cut a cam-shaped recess (d), which partly cocks the striker on turning up the bolt lever. On the opposite side is a small notch (d_2) for the tooth of the safety bolt.

On the German bolt is a small rib (a_2), which acts as a guide in withdrawing the bolt, and lies underneath the extractor, supporting it when the bolt is closed.

In the Turkish and Spanish patterns a shallow groove (d_3) is provided for the front tooth of the sear.

The mainspring B is of coiled wire ·06 thick, with 28 to 31 coils in the different patterns. **Mainspring.**

The striker C has a short point (e) and a collar (f), against which the mainspring bears. The end of the striker in the Belgian pattern is threaded, in the other patterns there are interrupted rings, near the end, for the attachment of the cocking piece. **Striker.**

The rear end of the striker C either screws into the cocking piece D, or is joined to it by the above-mentioned interrupted rings, in the latter case a quarter turn of the cocking piece releases it from the striker. On the under side of the cocking piece is a projection (g), which travels in a groove, cut for it in the tang of the body. This projection engages with the sear nose when the rifle is cocked. The front top surface of the stud (g) is bevelled off at (h) so as to work in the cam slot (d) in the rear of the bolt. In the German cocking piece the front end is bevelled off on both sides at (h_2). **Cocking piece.**

The bolt plug E screws loosely into the rear end of the bolt. The mainspring bears against the front end of it at (i). The cocking stud (g) works in the slot (g_1), and therefore the bolt plug cannot revolve with the bolt when the lever is raised. A rib (j) on the Belgian striker, and flats (j) on the strikers in the other patterns, prevent the striker from turning in the bolt plug. On top of the bolt plug is a cylindrical hole (r_1), for the stem of the safety bolt K. On the left of the German bolt plug is a pin (r_3), actuated by a spiral spring, which engages in the groove (d_3), at the rear of the bolt, when the lever is upright, and the bolt withdrawn. This is a special provision for preventing the bolt plug from being accidentally unscrewed when the bolt is withdrawn, and while the safety bolt is holding back the cocking piece. In the other patterns the front of the stud (h) on the cocking piece, resting in a small groove (h_1) on the rear of the bolt, prevents the bolt plug from turning if the safety bolt is not holding back the cocking piece. The flange (r_4) on the German bolt plug prevents the escape of gas into the firer's face in the event of a defective cartridge case. **Bolt plug.**

The safety bolt K consists of a thumb piece (s) and a spindle (r), which works in the hole (r_1) in the bolt plug. When the bolt of the rifle is closed, and the thumb piece is turned vertical, the flange (u) on the safety bolt is brought in front of the top of the cocking piece, and forces it back a little, withdrawing the stud (g) from contact with the sear. On turning the thumb piece over to the right, the cocking piece is still locked as above, but the end of the stem (r), where it is not cut away at (t), enters into the slot (d_2), on the end of the bolt, and thus locks the bolt and bolt plug together, preventing the former from being revolved. **Safety bolt.**

The Belgian safety bolt is retained in position by a small pin (v) actuated by the spiral spring (w), the former working in a groove (58) cut across the top of the bolt plug E. The spring (w) and pin (v) are retained in position by the screw (z). In the other patterns the safety bolt is retained in the two safety positions by the top of the cocking-piece bearing in shallow depressions (v_1, v_1) on the end of the safety bolt.

Extractor.

In the Belgian pattern the extractor is a short spring F, terminating in the usual claw (k). It is let into the right side of the bolt midway between the two locking lugs, and consequently revolves with the bolt. In the other patterns it is a long spring provided with an undercut groove (k_1). The spring band F_1 fits in the groove (k_3) in the bolt, and is capable of revolving round the latter. The two ends of the spring terminate in dovetail projections (k_2), which fit in the under groove (k_1) in the extractor.

The extractor works in the groove in the right side of the body, and is thus prevented from rotating when the bolt lever is turned up. The right-hand bolt lug lies in the recess (a) in the extractor when the bolt is drawn back.

Retaining bolt.

On the left side of the body is hinged a lever G, with a tooth (n) on it, which projects into the groove (14), in the body, for the left locking lug of the bolt. This lever is pivoted on the pin (p), and is kept pressed up against the body by the flat spring H, which is let into it. When pulled away from the body by means of the rib (o), the bolt can be withdrawn from the rifle. In the Belgian and Turkish models the rib (o) is replaced by a flap, shaped to lie up against the side of the body.

Ejector.

A flat piece, I, inside the retaining bolt, working on the same pivot pin (p), and actuated by the spring J inside the lever, projects into the boltway and forms the ejector. A slot (q) is cut for it in the left locking lug, and in the face of the bolt, so that when the bolt is drawn back the ejector springs into this slot. The base of the cartridge then strikes against the ejector, but as the extractor continues to draw back the right side of the cartridge, the latter is swung round and thrown out of the action to the right.

Sear.

The sear (17) projects into the groove cut in the tang (16) of the body, and is part of a bar pivoted near its front end to the body. It is actuated by a spiral spring (19), let into it, one end of which bears against the body. P (Plate XVI) represents the Spanish and Turkish sear, which only differs from the Belgian pattern in having a projection on the front end which engages in the groove (d_3) in the bolt, and in having the spiral spring vertical instead of horizontal. The German pattern is similar to the Spanish and Turkish, except that the projection at the front end is omitted.

Trigger.

The bar portion (18) of the sear has a vertical slot cut in it, in which the trigger (20) is pivoted. It has a double pull-off, of which the action is similar to that of the Austrian rifle.

There is no half cock, nor can the striker be placed at full cock without opening and reclosing the action.

Action of the bolt mechanism.

On the first motion of raising the lever (b) to open the action, the cocking piece D and the bolt plug E are prevented from turning with the bolt, owing to the cocking stud (g) projecting into the groove cut in the tang of the body. The tooth (h), on the cocking stud, is forced back by the cam recess (d) of the bolt; the striker is thus drawn back, and the mainspring partly compressed. While the lever is being raised, its lower end, at its point of junction with the bolt, moves against an inclined plane cut on the rear face of the cylindrical part of the body. This leverage causes the whole bolt to move a short distance to the rear, and constitutes the primary extraction or loosening of the empty case in the chamber. When the bolt lever has been turned through an angle of 90°, and is in a vertical position, the end of the cocking stud (h) or (h_2) rests in the notch (h_1) in the rear end of the bolt; the lugs (a) (and (a_1) in the German pattern) are in the grooves (14) in the body, and the rib (a_2), on the German bolt, is opposite its groove in the cylindrical part of the body. On drawing back the bolt the ejector I springs into its groove (q), so that the base of the cartridge on the left side strikes against it, and the cartridge is swung out of the rifle to the right. The left lug (a) then comes in contact with the tooth (n) of the retaining bolt, and the backward motion of the bolt is arrested.

On pushing the bolt forward, the ejector I is pressed to the left, the bottom of the bolt strikes the top cartridge in the magazine and pushes it forward into the chamber. As it does so, the base of the cartridge rises up the face of the bolt, and the extractor engages the groove of the cartridge. In the Belgian, Spanish, and Turkish patterns, when the bolt has about 1 inch further to travel, the cocking stud (g) is engaged by the sear (17), so that the cocking piece D and the striker C are held back while the bolt and bolt plug E are pushed forward, thus compressing the mainspring. On finally turning the lever down, the bolt is locked by the lugs (a, a) and (a_1) engaging in the recesses cut for them in the body. In the German bolt the cocking stud does not engage the sear until the bottom of the bolt lever meets the cylindrical part of the body; the mainspring is therefore finally compressed on turning down the bolt lever. This compression is materially assisted by the lugs on the bolt travelling along the cam-shaped entrances to their recesses, and being thereby forced forward. The striker C is released, as already described, and the tooth (h), or (h_1), on the cocking piece, entering the cam recess (d) on the bolt, the striker can reach the cap. If, however, the bolt is not completely closed, the travel of the striker is not complete, and the tooth of the cocking stud is not opposite the recess (d), so that the rifle is either not fired at all, or the closing of the bolt is completed by the tooth striking the side of the cam recess. In the

Spanish and Turkish patterns the sear (17) cannot be depressed until the bolt is completely closed, as the projection on the front end of the sear cannot rise into the slot (d_3), in the bolt, until the bolt lever is fully turned down.

Magazine. The magazine (21) in the Belgian, or earliest pattern, holds five rimless cartridges in a single column. It consists of a detachable sheet steel box, the bottom of which is hinged to the sides at its rear end (22), and secured by a screw (23) at its forward end. This screw serves also as the pivot of a flat lever (24), actuated by a flat spring (25) attached to the bottom of the magazine. Another flat lever (26) is hinged to the end of the first one, and forms the platform for the cartridge; another flat spring (27), secured to the lower lever (24), raises the upper one (26). The sides of the magazine are turned in at the top for nearly their entire length, to keep in the cartridges; they have both horizontal and vertical cuts in them, so that the sides form springs sufficiently elastic to open out when the cartridges are forced down into the magazine, but sufficiently strong to prevent the cartridge from being pushed out by the platform. The magazine passes up through an opening in the prolongation of the trigger guard, and is held in position by a small lever catch (28), pivoted in the trigger guard, and actuated by a small spiral spring (29). The magazine can be withdrawn on pressing the button (30) of the catch which projects through the front of the guard. For cleaning or repairs the screw (23) is withdrawn a few turns, when the bottom of the magazine, and the spring (25) attached to it, drops down; a few more turns of the screw enables the feeding lever to be disengaged; the screw is still engaged, and is therefore not liable to be lost.

The German, Spanish, and Turkish Mausers have a simpler and more compact magazine, shown in Figs. Q and R, Plate XVI. These magazines differ only in size to accommodate the various cartridges used in them. The body of the magazine (48) forms part of the prolongation of the trigger guard, and does not project below the bottom of the stock. The magazine opening in the body is slightly narrower than the magazine itself, so that the two columns of 2 and 3 cartridges respectively are pressed upwards against the overhanging edges, and are thus prevented from rising out of the magazine, as they can only come out of the central opening. The bottom of the magazine is closed by the plate (49). When this plate is pressed against the bottom of the magazine and pushed forward, the undercut ribs (50) and (51) on the plate enter the grooves (50a) and (51a), and the plunger (52), which is actuated by a spiral spring, enters the hole (52a) in the plate. The magazine spring (53), of ribbon steel bent into a zigzag form, has its ends secured in undercut recesses in the plate (49) and in the platform (54). The platform is provided with a rib (55) near its left side, which raises the column of cartridges resting upon it, and brings the centres of the cartridges in left column level with the tops of the

corresponding cartridges in the other column. In order to detach the plate (49), with the magazine spring and platform, for cleaning purposes, the plunger (52) is pressed in with the nose of a bullet, and the plate is freed from the magazine by sliding it to the rear. In the Spanish and Turkish patterns, when all the cartridges in the magazine have been expended, and the bolt is being pushed forward after extracting the last of them, the face of the bolt is caught by the rear end of the rib (55) of the platform, and is prevented from being closed until the magazine is refilled or the platform depressed with the finger. This arrangement informs the soldier in the heat of action that his magazine is empty. In the Belgian pattern there is no rib on the magazine platform, and in the German and Boer patterns the rear end of the rib is bevelled off to allow the bolt to pass over it.

The five rimless cartridges are held in a charger (see Plate LXI.) consisting of a strip of sheet steel with edges turned over thus [______], the edges entering the extractor groove cut in the base of the cartridge. A spring of wavy ribbon steel is secured to the inside, and holds the cartridge firmly in the charger. To fill the magazine, the charger is placed perpendicularly in position over it, the bottom of the charger being supported in a vertical groove cut for it in the body. The cartridges are forced out of the charger into the magazine by the downward pressure of the thumb applied just in front of the charger. The charger is thrown out by the bolt as it is pushed forward. The Turkish pattern is the only one provided with a cut-off. Charger.

The stock is in one piece; in the German pattern it is provided with a pistol grip. The stock, body, and trigger guard, are held together by the screws (31, 32). The former is screwed into a boss, which extends at right angles to the axis of the barrel; this boss communicates the recoil of the barrel and body to the stock and saves the screws (31) and (32) from being broken by the recoil. The Spanish and Turkish patterns have a handguard extending from the body to the lower band; in the German pattern the handguard extends from the backsight to the lower band. Stock.

In the Belgian, Spanish, and Turkish patterns the upper band (33) has a projection underneath it for the attachment of the sword bayonet in the usual manner. The nose-cap is a flat plate, either screwed to the stock, or pinned to it through a projection on the back of the plate. Bands, swivels, and nose-caps.

In the German pattern the upper band (56) is made of sheet steel, and is broader than usual. On its underside is a hook used for tightening the sling. The upper band covers a nose-cap (57), with long sword bar for fixing the sword bayonet and is fixed to the stock with a cross pin. In all patterns the lower band carries a sling swivel underneath. The bands are kept in position by means of spring catches let into the stock, either on the right-hand side or underneath. A second swivel is pivoted on a plate screwed on to the underside of the butt.

Cleaning rod.

All patterns are provided with a cleaning rod. In the Belgian pattern it is of full length and screws into a nut in the stock. The head has a slot in it, and fits into the rod holder (4) of the foresight ring.

The Turkish pattern has a full length rod screwing into a nut in the stock.

The Spanish and German patterns have a half length rod, one end of which screws into a nut in the stock. The other end is provided with a slot for the rag, and is tapped to allow of two rods being joined together.

Butt plate.

The butt plate is of steel secured by two screws; it has no trap. The German butt plate is thin, but unusually broad at the toe.

Sword bayonets.

The German bayonet is fixed solely to the strong sword bar attached to the nose-cap; there is no cross piece on the side of the hilt next the barrel. The bayonet is unusually long; it is provided with a straight rib which forms the back for two-thirds its length, but from the point for one-third of its length the blade extends on both sides of the rib and is double edged. A bayonet is not used with the Boer Mauser.

The blade of the Turkish bayonet is rather long; it is double edged near the point. A groove, or fuller, runs parallel with, and close to, the back for two-thirds the length of the blade.

The blade of the Spanish bayonet is very short; it has a broad back, and a broad flat-bottomed fuller runs to within an inch of the point. The blade is double edged for about 1 inch.

The Belgian bayonet is similar to the Spanish. The scabbards for the above bayonets are made of black leather, with steel lockets and chapes; the lockets are provided with steel studs to enable them to be attached to the waistbelt frog. The steel work of the above bayonets and scabbards is left bright.

For weights and dimensions see Table IV, Appendix.

SPAIN.

Mauser carbine. 7 *mm.* ·275-*inch.*

This carbine is similar in construction to the Spanish Mauser rifle with the following exceptions:—

Sights.

The backsight leaf is graduated from 400 to 1,400 metres.

Bolt.

The bolt lever is turned down so as to lie close to the stock.

Nose-cap and bands.

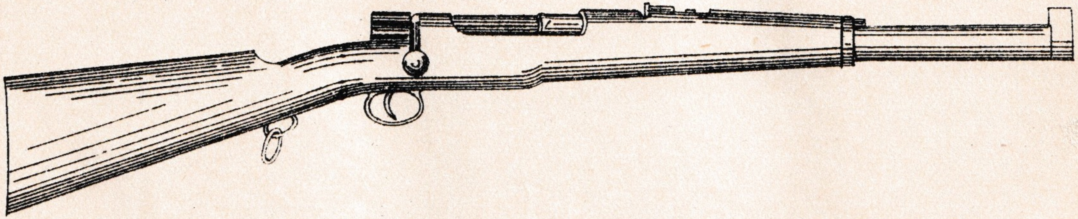
The barrel projects $\frac{1}{16}$-inch through the nose-cap. The latter is extended upwards at the sides to form wings for the protection of the barleycorn; it is also raised in front to the height of the foresight block for the protection of the latter. It is not provided with a sword bar.

The lower band carries a sling swivel on the right-hand side. A plate is attached by two screws to the stock, just below and in rear of the small. Carried on a staple fixed to this plate is a ring for the attachment of the other end of the sling.

Plate XIX.

SPAIN. MAUSER CARBINE.

To face page 50.

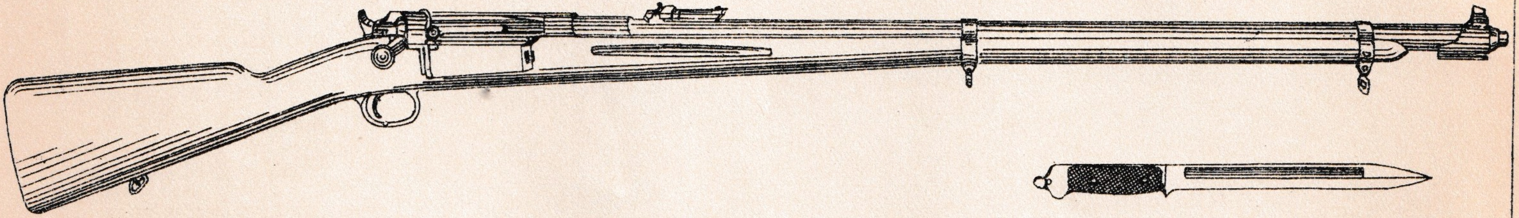


2310

Weller & Graham, Ltd. Litho. London.

Plate XX.

DENMARK. KRAG-JORGENSEN 1889.



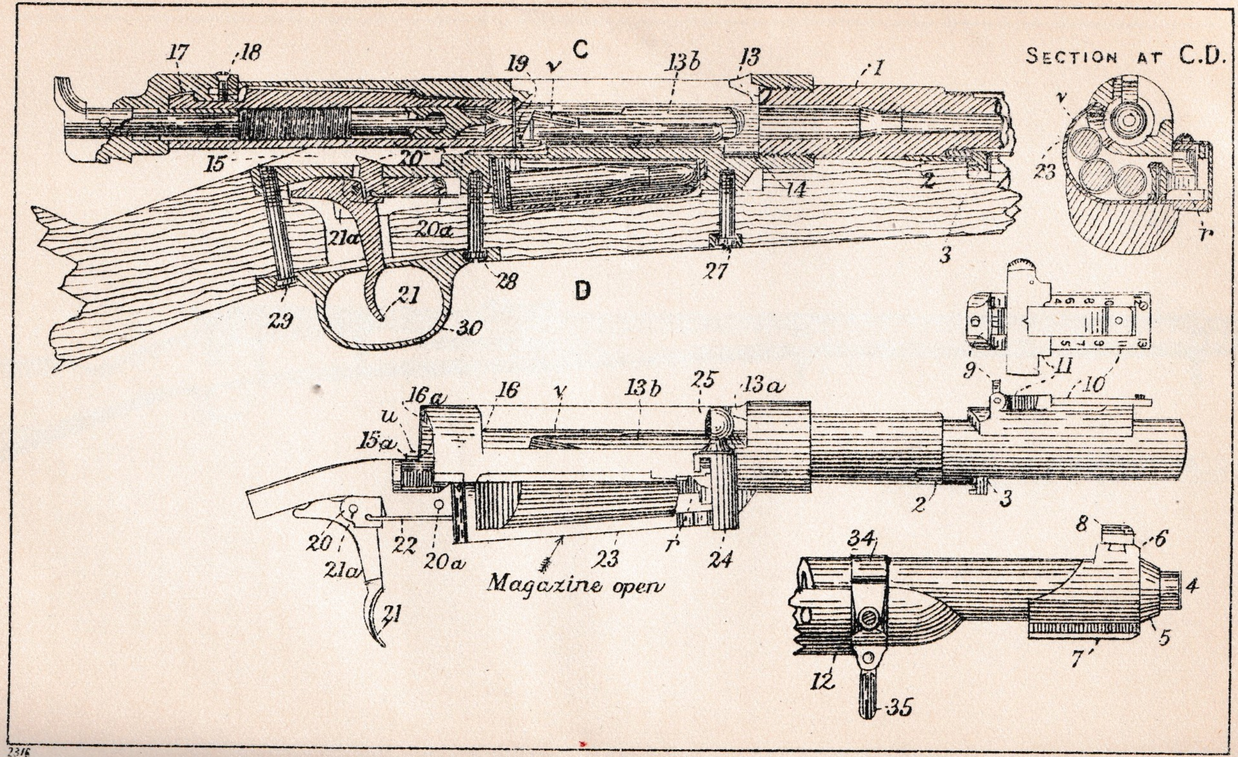
To face page 51

2 2310

Weller & Graham. Ltd. Litho. London.

DENMARK, 1889 KRAG JORGENSEN

Plate XXI.



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2316

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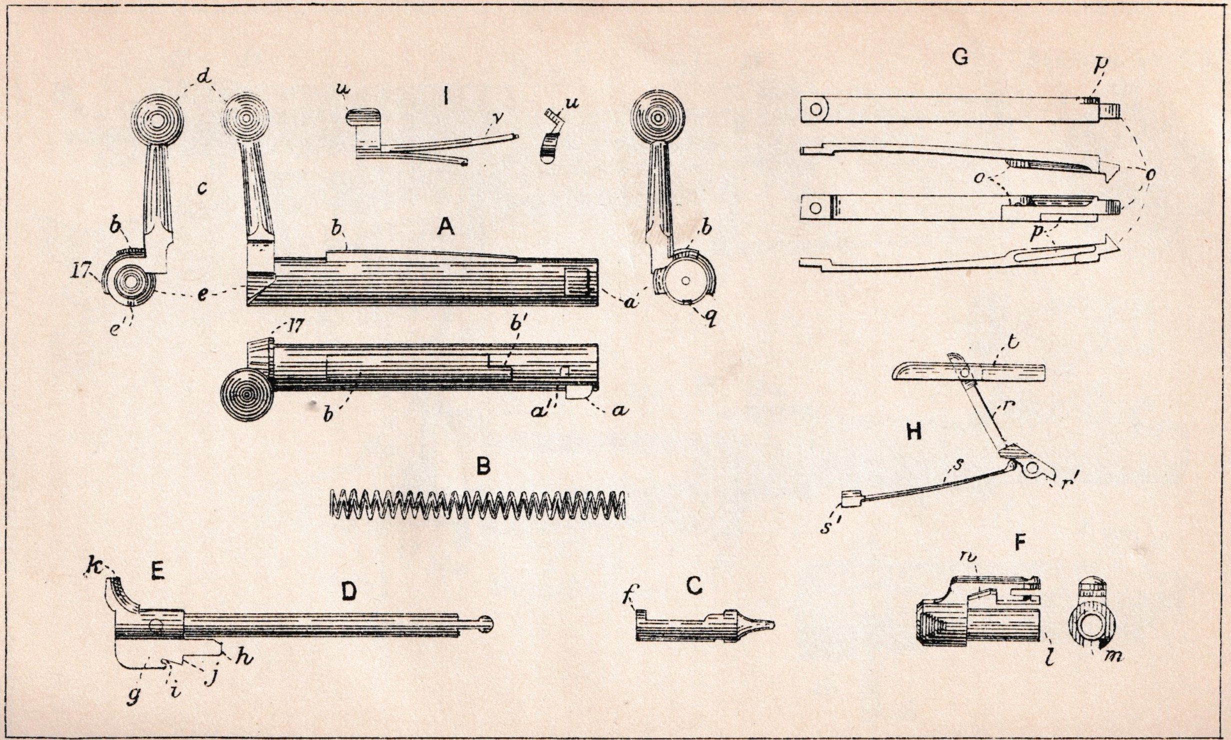
DENMARK. 1889. KRAG JORGENSEN.

Plate XXII.

To face page 51.



2316

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DENMARK.

Krag Jorgensen. 8 *mm.* ·315-*inch, pattern* 1889.

The barrel, which is moderately thin, is reinforced at the breech end. It screws into the body, and is finished turned and browned externally. **Barrel.**

It is protected, like the Belgian rifle, by a cylindrical casing, which screws on to the barrel (1) just in front of the reinforce and is secured by a short spring catch, one end (2) of which dovetails into the reinforce, while the other (3) fits into a hole cut for it in the casing. The muzzle (4) projects for about $\frac{1}{4}$-inch beyond the casing. The front end of the casing has a strengthening piece (5), brazed on, which carries the foresight block (6), and a bar (7) for the attachment of the sword bayonet. **Casing.**

The barleycorn foresight (8) is dovetailed into its block at right angles to the axis of the barrel. The backsight bed is secured to the casing by two screws passing up from the inside; it has a fixed sight (9) with V notch for 300 metres range, and the usual leaf (10) and spring. The leaf is graduated in front for ranges from 400 to 1,300 metres, and at the back for ranges from 1,400 to 1,900 metres. There is no cap, but the sides are connected by a flat cross-bar. The slide (11) with V notch, when at the bottom of the leaf, in the upright position, gives the elevation for 400 metres. The leaf is retained in position at any graduation by a small spring pawl pivoted in its left side, the tooth of which engages in notches cut in the left side of the leaf, corresponding to the graduations. On the right side of the slide is another V notch, which is used for ranges from 1,400 to 1,900 metres, in conjunction with a flat button (12) screwed into the right side of the upper band. **Sights.**

The body is bored longitudinally for the bolt, and is cut away on the right, to allow of the empty case being ejected, and to facilitate single loading. The rear part of the body does not form a complete circle, but is slotted out on top to admit the extractor, and to give clearance for the lug, when taking out the bolt. The magazine is a horizontal one screwed on beneath the body, and having its opening (13*b*) on the left of the boltway. The body is prolonged to form a ang behind, and a groove (15) is cut in this portion for the cocking stud, a vertical slot being cut in the groove for the bent of the sear. On the right side a recess (15*a*) is cut for the bolt lever. At the front end of the boltway there is a recess (13) for the end of the extractor, and below this another (14) for the locking lug (*a*) on the bolt. On the left side of the boltway in front is a projection (13*a*) which holds down the extractor. **Body.**

The face of the bolt cylinder, A, is recessed for the base of the cartridge, which has a rim. There is no separate bolt-head. **Bolt.**

A single locking lug (a) is situated at the head of the bolt. On the right side, when the bolt is closed, is a solid rib (b) which bears against a shoulder (16) in the body, and assists in taking the shock of recoil. The lever (c), terminating in a knob (d), is at the rear end of, and at right angles to, the bolt cylinder. A cam-shaped recess (e) is cut in the back of the bolt. On the rear end of the bolt is a small groove (e_1) in which the point (h) of the cocking stud rests when the breech is open. A gas escape hole (a_1) is bored in the right side of the bolt cylinder.

A flange (17) runs partly round the rear end of the bolt and serves to retain the sleeve F. The bolt can be stripped without the aid of tools.

Mainspring. The bolt is bored out from the rear for the mainspring, B, which is of ″·053 wire, with 28 coils set to a length of 4·5 inches.

Striker. The striker is in two pieces, the point, C, forming the front end of a hollow cylinder which fits over the other portion, D, and is secured to it by a sort of knuckle joint. The mainspring bears against the rear end (f) of the front part of the striker.

Cocking piece. The rear portion, D, of the striker, screws into the cocking piece, E, from which the cocking stud (g) projects downwards, travelling in the groove (15) cut for it in the tang of the body. The front of the stud (h) is shaped to fit into the cam recess (e) of the bolt. The stud is provided with a half bent (i), as well as a full bent (i), and the cocking piece has a roughened thumbpiece (k).

Bolt sleeve. The striker passes through a sleeve, F, which fits into the rear portion of the bolt, and against which the mainspring bears at (l). The sleeve is bored out for the cocking piece, and has a slot (m) in its underside for the cocking stud to travel in. On the top it extends over the bolt, travelling in the slot cut in the body cylinder; a groove (n) is cut in this portion of the sleeve, in which a corresponding flange (17) on the rear of the bolt works, and prevents the pressure of the mainspring at (l) from forcing the sleeve out to the rear.

Extractor. The extractor, G, which is a long flat spring terminating in the usual claw (o), is pivoted by a screw (18) to the bolt sleeve, and fits over the bolt rib, when the bolt lever is raised. It has a secondary spring (p) mortised into it, which fits under the projection (13a) in the body, and prevents the extractor from rising during primary extraction. The extractor claw projects over the face of the bolt head recess. When the bolt is closed the end of the extractor fits into the recess (13) in the body, but when the bolt lever is raised the projection (b_1) on the front of the rib of the bolt bears against the projection (o_1) on the extractor, guiding the latter while the bolt is being drawn back. The slot in the cylindrical portion of the body assists in performing the last-mentioned function.

Retaining arrangement. There is no retaining bolt, but the lug on the bolt coming up against the resisting shoulder (16) stops the backward movement of the bolt. To remove the bolt it must be drawn back,

the extractor lifted so as to clear the top of the body, and the bolt lever turned to the left—this brings the lug opposite the slot in the body cylinder, when the bolt can be withdrawn.

The ejector (19) is a spring, dovetailed into the bottom of the boltway. Its front end projects upwards and enters the groove (q) in the head of the bolt, when the latter is drawn back. On the base of the cartridge striking the ejector, the cartridge is rotated upwards and to the right, and is ejected from the action. Ejector.

There is no locking or safety bolt. The striker can be placed at half and full cock without opening the action. Safety bolt.

The sear (20) is pivoted underneath the body on the pin (20a); the bent of the sear projects into the groove (15) in the tang. The sear is actuated by the flat spring (22) let into it. Sear.

The trigger (21) is a bent lever pivoted on the pin (21a) in a slot at the rear end of the sear. The trigger has two ribs on its upper surface, which bear in succession against the underside of the tang, and produce the double pull-off, fully described in the Austrian Mannlicher pattern 1888/1890. Trigger.

On first raising the bolt lever the point of the cocking stud (h), which is prevented from rotating by the groove (15), is forced back by the cam surface of the recess (e) and drops into the groove (e_1). As the bolt lever is being raised it is forced back by the curved surface of the back of the body at (16a). This effects the primary extraction. While this is taking place the extractor is held firmly down on the cartridge by the projection (13a) on the body. The extractor is pressed to the left by the projection (b_1) on the bolt bearing against the projection (o_1) on the extractor. The bolt can now be drawn back as the lug (a) has been withdrawn from its recess (14), and the rib (b) is opposite the opening in the rear part of the body. As the bolt is withdrawn, the point of the ejector (19) enters the groove (q) in the bolt-head, and ejects the cartridge as before described. The backward motion of the bolt is stopped by the lug (a) striking the shoulder (16) on the body. On pushing forward the bolt the left edge of the face of the bolt strikes against the base of the cartridge which projects partly through the opening (13b) in the body, and pushes it forward into the chamber. The bent (j) on the cocking piece meets the bent of the sear (20) at the same time as the bolt lever meets the surface (16a) on the body. As the bolt lever is turned down the lug (a) on the bolt passes down a cam-shaped groove to its seating (14). This forces the bolt fully home and completes the compression of the mainspring. Action of the bolt mechanism.

The magazine (23) is a sheet steel box, secured by two screws to the underside of the body. It passes underneath from right to left, and turns up on the left side opposite the opening in the body. It has a door (24) on its right side hinged to it in front, and secured in rear by a spring catch with knob (25). The mechanism, H, for feeding the cartridges, is attached to the door, and consists of a lever (r) actuated by a flat Magazine.

spring (s), the end of which (s^1) is dovetailed into the door of the magazine, and the platform (t), which is hinged to the lever. When the door is fully open, the rear arm (r^1) of the lever is engaged by a projection on the front of the magazine, and by this means the lever and platform are held back against the door, permitting of the free introduction of the cartridges. When the door is closed the lever is released, and, with its platform, is pressed to the left by the spring, forcing the cartridges, forward and upwards, into the opening in the body; the rear end of this opening is however not broad enough to allow the base of the cartridge to pass through. When the bolt is pushed to the front, its face catches the rim of the cartridge on its right side and moves it forward, the bullet being guided into the chamber along an incline in the left side of the body, until the base comes to the enlarged portion of the opening, when the whole cartridge clears the magazine and is forced into the chamber by the bolt. The magazine can be charged with the bolt either open or closed, and can be replenished at any time with one or more cartridges.

Cartridge charger. The magazine can also be filled by means of a charger holding five rim cartridges. The charger is a steel box of rhomboid form, open at one of the long sides, and partially so at the top. An iron rod with handle is secured to the top, the ends of the rod being turned over, so that, when the handle is down, the end of the rod prevents the cartridges coming out at the open side. To charge the magazine, the door is opened, the charger put up against the magazine, the handle raised, and the cartridges emptied in by slightly inclining the rifle to the left.

Cut off. The cut off, I, is a split spring pin, working in a hole bored in the left side of the body parallel to the bolt, and terminating in a thumbpiece (u). One blade (v) of the pin is eccentric and longer than the other, and when the thumbpiece is turned up the blade projects into the cartridge way and keeps back the cartridges.

Stock. The stock is in one piece, without pistol grip, but with fore-end grooves for the fingers and thumb of the left hand. The stock and body, with magazine, are secured together by three screws passing up from below; one (27) of these screws into a boss on the underside of the body in front of the magazine, the other two (28) and (29), through the trigger guard and stock, into the body and tang. The trigger guard (30) is a separate component of the ordinary pattern.

Band and swivels. The lower band, with sling swivel, is secured by a spring catch let into the underside of the stock. The upper band (34) carries a piling swivel (35), and the long range bead foresight (12), is secured by a screw. A second sling swivel is screwed into the butt. There is no nose-cap, and the end of the stock is rounded off. The butt plate is of steel secured by two screws. No cleaning rod is carried in the rifle. A whipcord pull-through is provided. A sight protector is issued with the rifle.

Plate XXIII.

FRANCE. LEBEL 1886.

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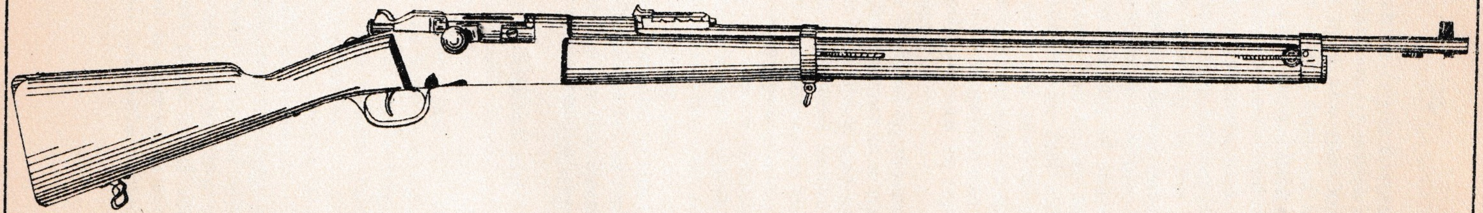

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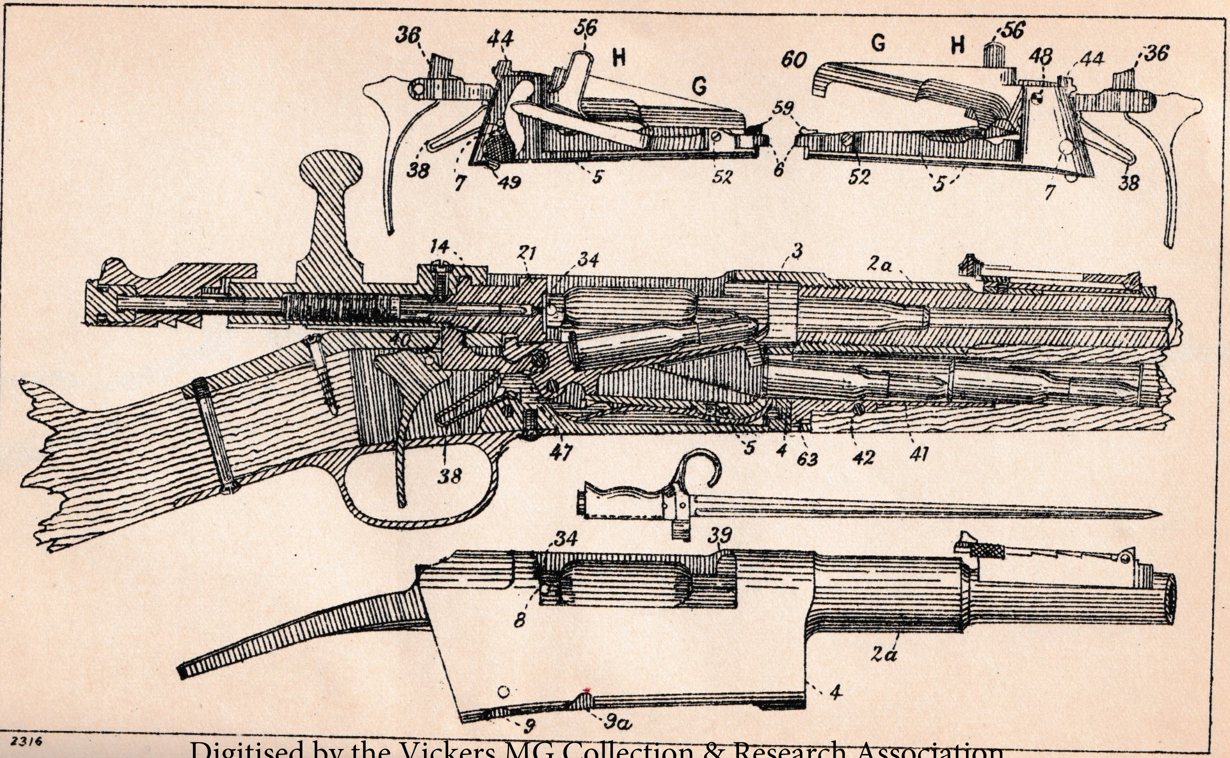
FRANCE. LEBEL RIFLE, 1886.

Plate XXIV.



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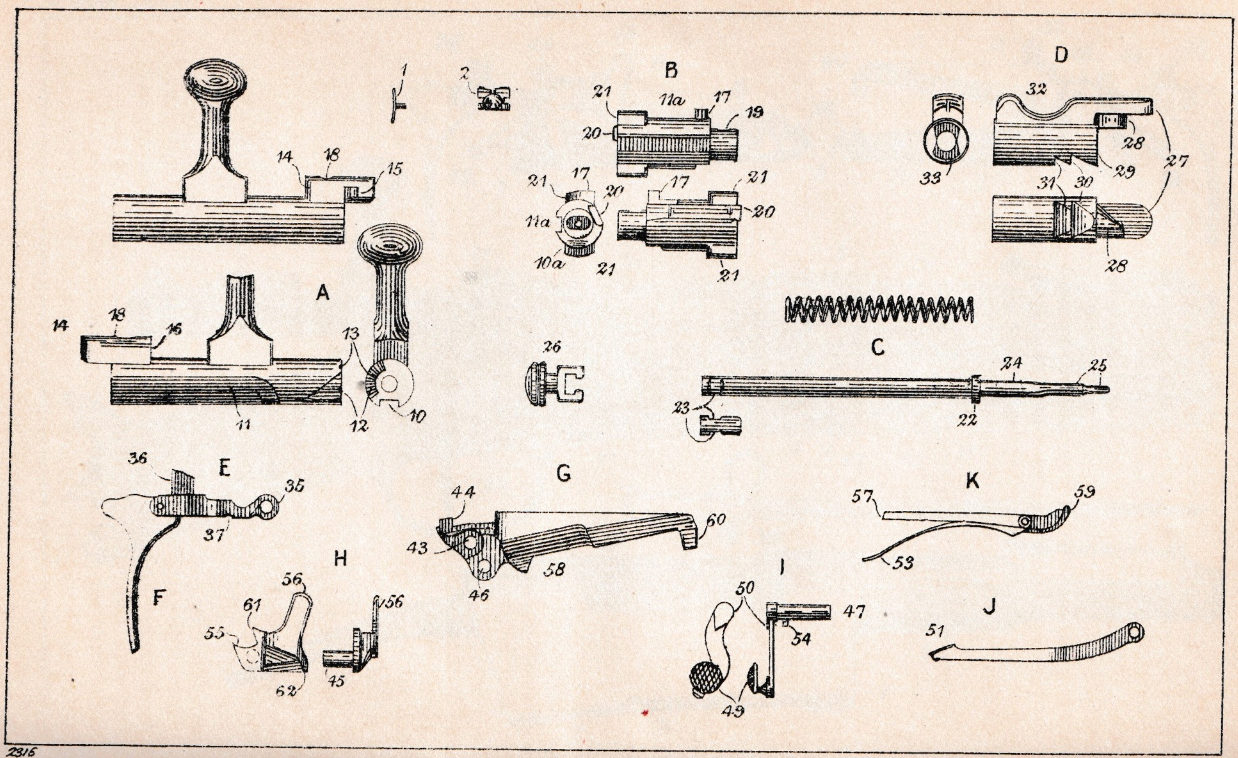
FRANCE. LEBEL RIFLE. 1886.

Plate LII

To face page 55.



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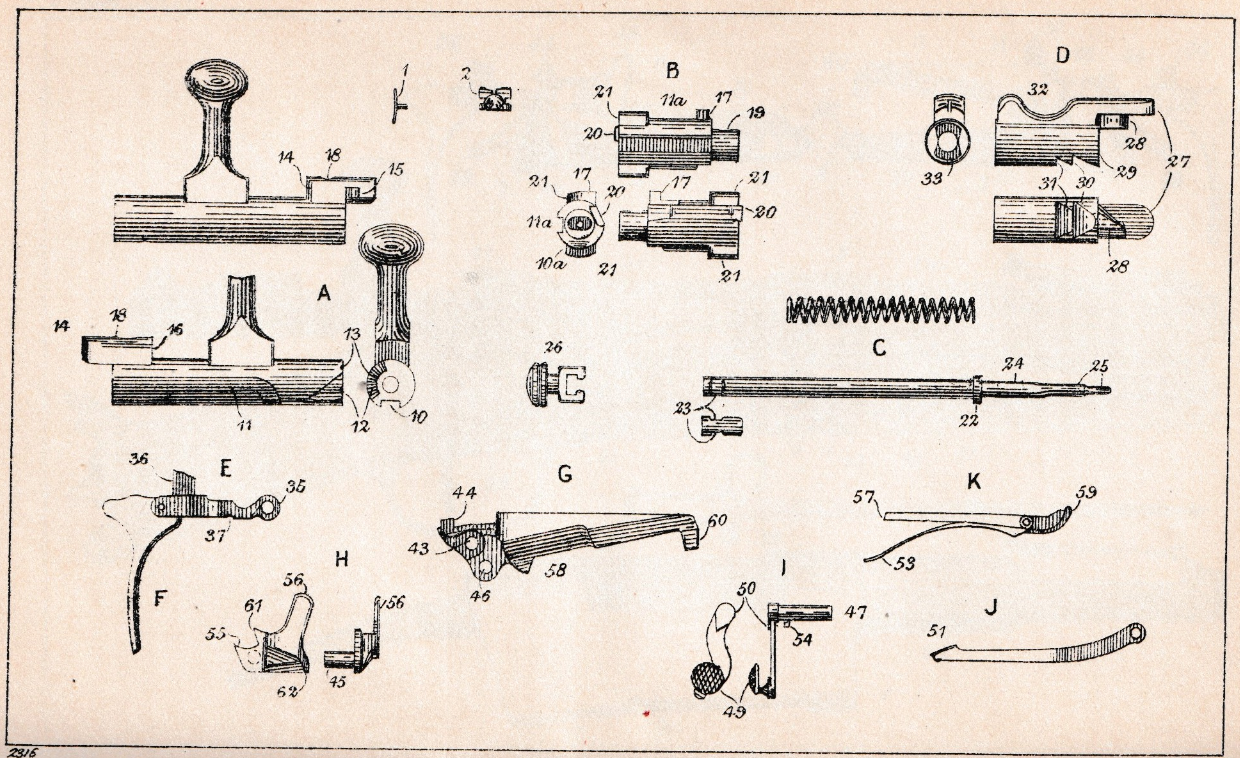
FRANCE. LEBEL RIFLE. 1886.

Plate IIV



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2316

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is prolonged forwards at (40) between the sides of the body. The bolt slides in a longitudinal groove, cut in the upper part of the body, and the lugs (21) on the bolt-head turn into recesses (3) at the front end of the bolt way. The entrances to these recesses are rounded off to allow of the bolt coming back during primary extraction. At the front end, below the projection (2*a*), is an opening (4) for the magazine tube. The bottom of the body is closed by a plate (5) to which is attached the sear and the cartridge elevating mechanism, which are situated below the boltway. The projection (6) on the front end of the plate fits into a recess in the body, and a screw passes through the body and through a screw-hole (7) in the rear end of the plate. The body is cut away on the right side to allow of the cartridge cases being ejected to the right. The rear part of the boltway is open on top to allow of the passage of the rib (14), on the bolt, and also of the bolt lever, which turns down in front of the shoulder (8). Two recesses (9) and (9*a*) are cut in the bottom of the right side of the body for the handle of the carrier axis-pin lever (49).

Bolt.

The bolt A is a strong cylinder, bored out from the front for the mainspring. It has a straight lever terminating in a knob. On the opposite side to the lever is a groove (10) into which the nose of the sear projects. On the left side, with the lever in the raised position, is the groove (11) for the ejector (34). On the same side is cut, at the rear end of the cylinder, a cam-shaped recess (12) for the similarly shaped projecting tooth (28) on the cocking piece. When the bolt lever is raised the end of the tooth (28) rests in the recess (13). The projecting rib (14) extends beyond the face of the bolt, and serves to connect the bolt-head and bolt by means of the recess (15) fitting over the stud (17) on the bolt-head. A screw passes through the hole (18) in the bolt and enters the hole (19) in the bolt-head tenon, which in turn enters the mainspring channel of the bolt-head; the latter is therefore forced to turn with the bolt. This rib also acts as a guide to the bolt, the small rib (16) travelling along the left top edge of the body.

Bolt-head.

On the left of the bolt-head B is the ejector groove (11*a*). On the right, the extractor (20) fits into an undercut groove, the rear end being splayed out slightly to resist the pull during extraction. The two lugs (21) enter the recesses (3) in the body on the right and left of the boltway, and prevent the bolt being forced to the rear on firing. The face of the bolt-head is cupped out to a depth equal to the thickness of the cartridge rim; the extractor, therefore, will not rise over the rim of the cartridge until the cartridge is almost home in the chamber. The bolt-head is bored out for the striker, the hole in rear being oval to receive the part (24) on the striker. The groove (10) on the bolt for the sear nose is continued for a short distance along the bolt-head at (10*a*).

Mainspring.

The mainspring consists of 19 coils of wire, ·05 inch thick, set to a length of 3·9 inches.

The striker has a shoulder (22) for the mainspring to bear against, and two slots (23), near the rear end, fit into the T-shaped recess in the striker knob (26). The part that enters into the bolt-head is thinned down in front of the shoulder at (24). The point is further reduced in two steps at (25). Striker.

The cocking piece D has a projection (27) in front, working in the opening between the sides of the body. Underneath the projection is a tooth (28) which is shaped to fit into the cam recess (12) at the back of the bolt cylinder. The bottom front corner (29) of the cocking piece is the full cock bent. The notch (30) is a second full cock bent. The notch (31) affords clearance for the bent of the sear, when the cocking piece is forward in the fired position. The top is hollowed out and roughened to form a comb for drawing back, or letting down the striker, but the mainspring is too strong for this to be done with safety. The striker passes through the cocking piece, its knob fitting into the recess (33) in the rear end of the latter and being locked with a half turn. Cocking piece.

The extractor (20) is a short flat spring terminating in the usual claw, which projects over the face of the bolt-head; it is dovetailed into its groove in the bolt-head. The breech end of the barrel is bevelled off for a quarter of its circumference to afford clearance for the claw of the extractor. Extractor.

The ejector is a small pin (34) screwed into the body on the left side, it projects into the boltway and works in the slot (11) and (11*a*) in the bolt and bolt-head. Ejector.

The sear E is pivoted on the carrier axis pin (47) which passes through its front end (35). The bent of the sear (36) projects through an opening in the partition (40) into the boltway. The sear is pressed upwards by a V-spring (38), one end of which engages in the recess (37) in the sear, the other end being fixed by a small screw which passes across the bottom plate. Sear.

The trigger F is pivoted in a fork at the end of the sear. It has two ribs on top which give the double pull-off as described in the Austrian rifle. Trigger.

On turning up the bolt lever the tooth (28) on the cocking piece rides up the inclined face of the cam recess (12) on the bolt, and the point of the tooth drops into the recess (13). This compresses the mainspring nearly to its full extent. The cocking piece is prevented from turning with the bolt by the projection (27) being supported by the sides of the body. As the bolt is being opened the lugs (21) on the bolt-head are turned from in front of their supports into a vertical position, and the front end of the projection (14), on the bolt, is forced back by the curved face of the body at (39); this effects the primary extraction. The bolt lever and rib (14) are now in line with the opening between the sides of the body, the ejector screw is in the groove (11) and the groove (10) in the bolt is opposite the projecting sear bent (36), and the bolt and the Action of the breech mechanism.

empty cartridge can be drawn back. When the bolt is fully back it is stopped by the lower lug striking the end of the partition (40) in the body. At the same time the end of the ejector screw (34) strikes behind the left edge of the cartridge rim, and ejects the empty cartridge to the right. On pressing the bolt forward, the face of the bottom lug strikes the base of the cartridge in the carrier, which has just been raised, and pushes it forward into the chamber. As the front of the rib (14) meets the curve on the front of the body (39), the sear bent (36) engages the bent of the cocking piece (29). On turning down the bolt lever, the lugs (21) on the bolt-head pass along the curved entrances to the recesses (3) and force the bolt fully home, completing the compression of the mainspring. The claw of the extractor springs over the rim of the cartridge, and travels round the bevel cut for it on the face of the barrel, while the bolt handle turns down in front of the shoulder (8) on the body.

Magazine and cartridge raising mechanism.

The magazine consists of a longitudinal hole bored in the fore-end, lined towards the rear with a short steel tube (41), which is kept in position by a pin (42) through the fore-end. It holds eight cartridges, which are pressed to the rear by a steel spiral spring consisting of 78 coils of wire ·03 inches thick. The rear end of the wire is fixed in a steel plunger, which is prevented from coming out of the tube by a small shoulder in the latter. The cartridges are raised by a carrier G, in the form of a scoop, which is pivoted at (43) on the stem (47) of the carrier axis pin I, which passes through a hole (48) in the vertical sides of the bottom plate. On the rear end is a tooth (44). The depressor H is provided with a pin (45), which fits in the hole (46) in the carrier. On the end of carrier axis pin I is a lever, terminating in a chequered button (49). At the top of the lever is an undercut projection (50), against which the end (51) of the retaining spring J bears. The retaining spring is pivoted on the screw (52) in the bottom plate. The elevating lever K is pivoted on the same screw; it is pressed upwards by the spring (53) which is screwed to it.

The action of the cartridge elevating mechanism, and the magazine are as follows:—Suppose the breech closed and the button (49) of the carrier axis pin lever is to the rear, then the stud (54) on the carrier axis pin is bearing on the surface (55) of the depressor. This causes the arm (56) of the latter to stand well above the top surface of the carrier. On closing the breech the bolt lever strikes the arm (56) and forces the carrier down. The end (57) of the elevating lever is depressed and bears against the front face of the projection (58) on the carrier and holds it down. The interrupting tooth (59) on the elevating lever spring is raised, so that it would catch the head of any cartridge coming from the magazine. On drawing back the bolt, the bottom lug on the bolt-head strikes the tooth (44) on the carrier, and raises the front end of the

latter. The end (57) of the elevating lever rises under the projection (58) on the carrier and presses it upwards. The interrupting tooth (59) is depressed, and would let the next cartridge by, but the cartridge head would be stopped by the toe (60) of the carrier. To load the magazine, depress the carrier with the bullet of the cartridge, and press the latter into the magazine; the interrupting tooth (59) will be depressed as the rim of the cartridge passes over it. When the magazine is full, place a 9th cartridge in the carrier, and jerk the bolt back to raise the carrier. The head of the rear cartridge in the magazine has now passed over the interrupting tooth and is pressing against the toe of the carrier. On closing the breech, the cartridge in the carrier is loaded into the chamber, and the bolt lever depresses the carrier, and raises the interrupting tooth. The cartridges in the magazine are pressed to the rear by the magazine spring, the rear cartridge enters the carrier, but the head of the next cartridge is stopped by the interrupting tooth (59). On opening the breech again the carrier is raised, and the operations repeat themselves as before. When it is desired to retain the magazine full, and use the rifle as a single loader, the button (49) of the carrier axis pin lever is pushed to the front. The stud (54) on the carrier axis pin then presses on the surface (61) of the depressor, and the latter turns on its pin (45) so that its arm (56) does not stand sufficiently above the carrier for the bolt lever to strike it. The corner (62) of the depressor then rests on the bottom plate and prevents the carrier from being depressed.

Stock and trigger guard.

The stock is in two pieces. The butt is fixed to the body by a screw passing up through the rear end of the trigger guard into the tang of the body, and by another passing through the tang into the butt. The trigger guard is of the usual pattern, its front end fitting into an undercut groove in the bottom plate, and being secured by a screw. The recoil of the barrel is communicated through the body, to the front end of butt. The fore-end is attached to the barrel by the nose-cap, and band. It is prevented from sliding forward, by a hook (63), on the bottom of the magazine tube, engaging in a recess in the body. There is no handguard or cleaning rod. The butt plate is plain and is secured by two wood screws.

Nose-cap and bands.

The nose-cap is combined with a rather broad upper band, and has on its front a circular projection, into which the pommel of the bayonet fits. A short stud on the end of a spring, let into the right side of the fore-end, fits into a hole in the nose-cap and secures it. The lower band is a plain steel band, on the bottom of which is a sling swivel. It is kept in position by a spring, let into the fore-end. The other sling swivel is pivoted to a plate, which is attached to the bottom of the butt by two screws.

Two cleaning rods, one with a steel loop, the other with a bristle brush, are used in barracks for cleaning and greasing respectively; in the field a pull-through is used.

Bayonet.

The long bayonet is +-shaped in cross section. The cross piece fits over the muzzle of the barrel, the end of the pommel fitting into the recess in front of the nose-cap, and the spring catch in the hilt engaging behind the long projection under the barrel, and preventing the bayonet from sliding forward.

For weights and dimensions, see Table IV, Appendix.

FRANCE.

Carbine. 8 *mm.* ·315-*inch*, *Pattern* 1890.

This carbine is of a different type to the Lebel rifle. It fires the same cartridge, but the magazine, instead of being in the fore-end, is a box magazine, with an opening in the bottom, of the Mannlicher type, and is loaded by a clip containing 3 cartridges. The bolt is somewhat similar to that of the Lebel, and has a revolving bolt-head which carries the locking lugs. The bolt lever is bent down to enable the carbine to be easily carried in a bucket. The stock is in one piece; it extends downwards in front of the trigger guard so as to cover the magazine. The barrel is held down in the fore-end by an upper and lower band. There is no handguard.

GERMANY.

Mauser. 7·9 *mm.* ·311-*inch*, *Pattern* 1898.

See Mauser rifles, page 42.

GREAT BRITAIN.

Rifle Charger Loading, M.L.E., 7·7 *mm.* ·303-*inch*, *Pattern* 1907.

See Table VII, Appendix.

The Lee-Metford Mark I rifle was the first magazine rifle adopted for the British service; this was converted to Mark I*, the pattern of which was approved 19th January, 1892. It was followed by the Lee-Metford, Mark II, approved 30th April, 1892. The Lee-Metford, Mark II*, was next approved on 22nd April, 1895; it differs from the Mark II in having a safety catch added to the bolt. The Lee-Enfield, Mark I, approved 11th November, 1895, followed the Lee-Metford, Mark II*, and differs from it only in having Enfield rifling in place of Metford, and in the lateral position of the foresight.

To face page 60.

FRANCE. CARBINE, PATTN. 1890.

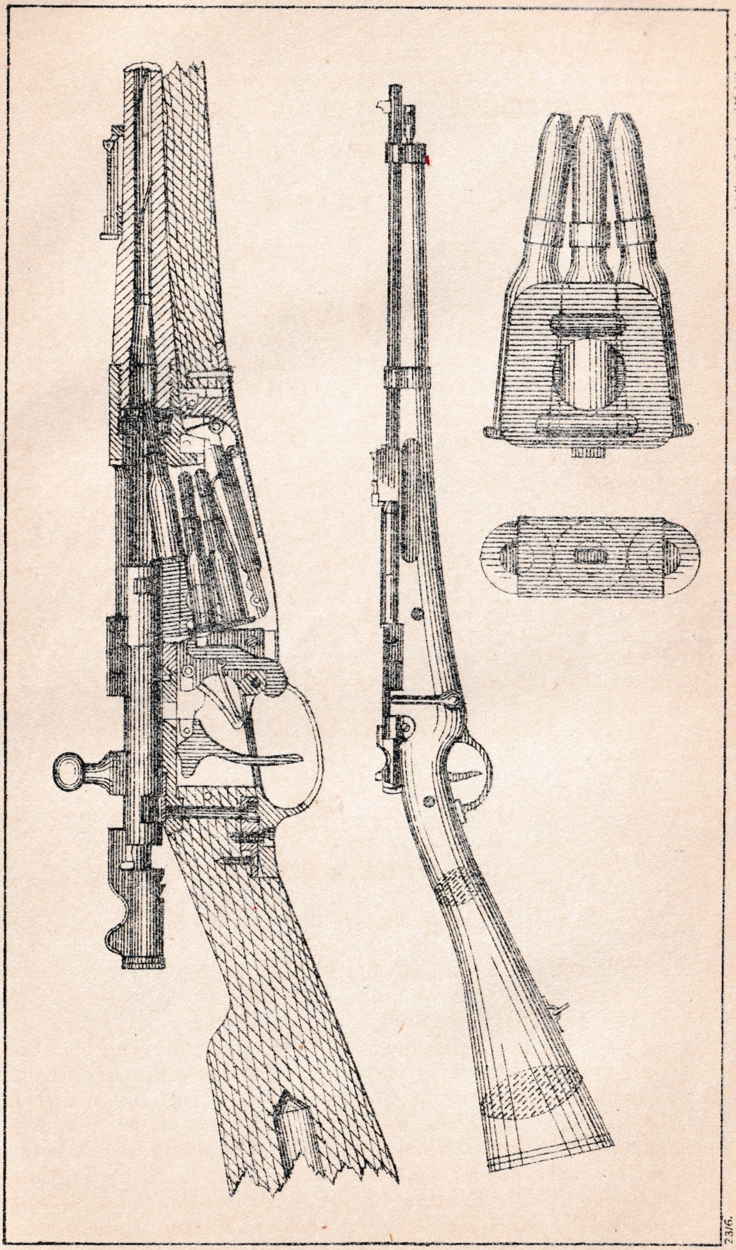
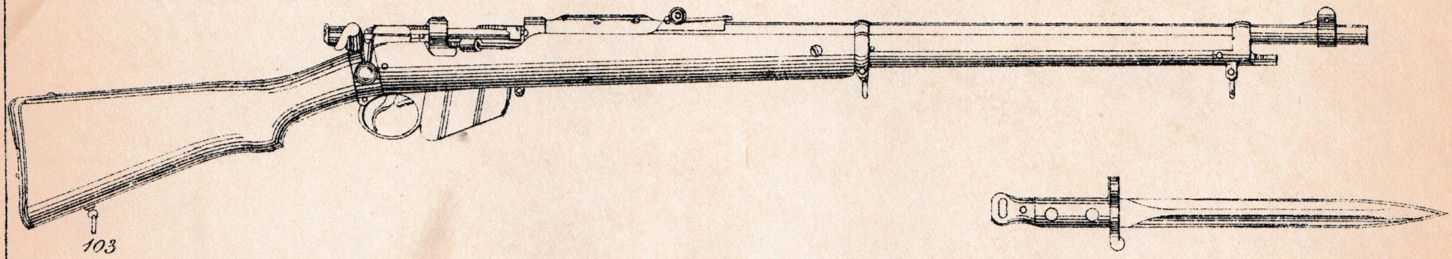


Plate XXVI.

GREAT BRITAIN. CHARGER LOADING LEE-ENFIELD.

Plate XXVII.

To face page 61.



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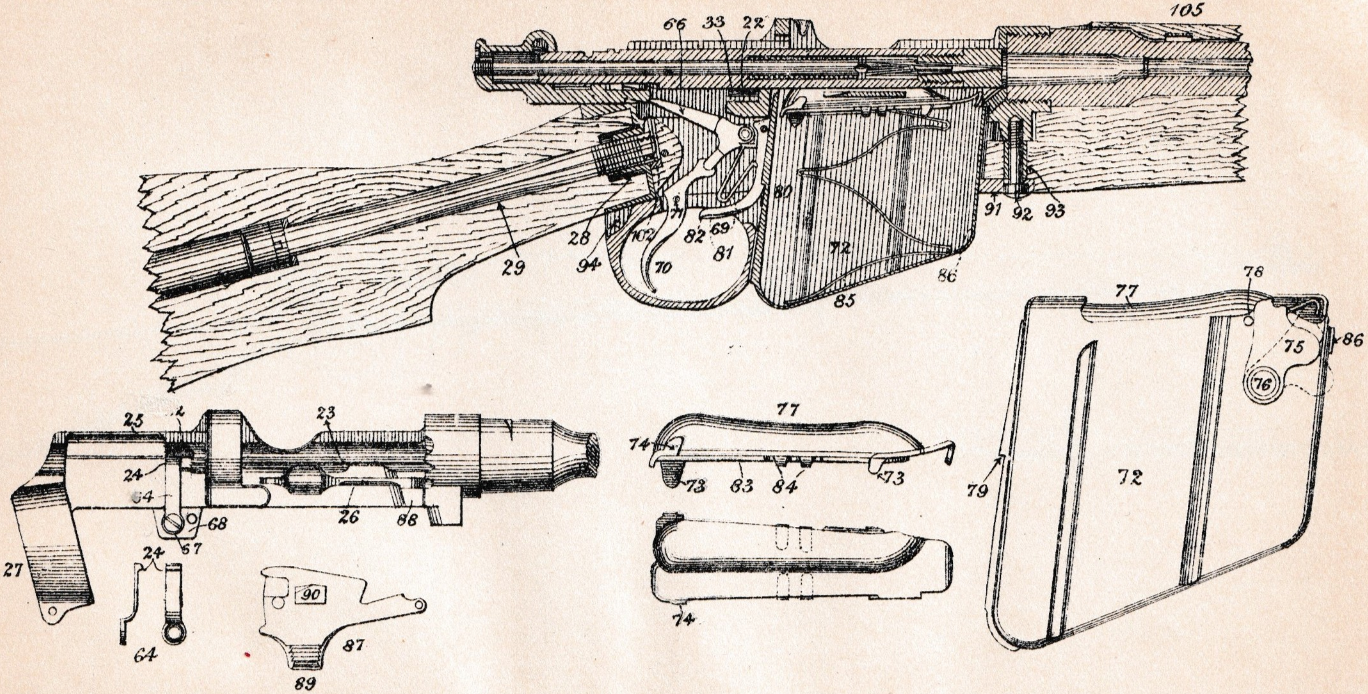
GREAT BRITAIN, CHARGER LOADING LEE-ENFIELD.

Plate XXVIII.

To face page 61.



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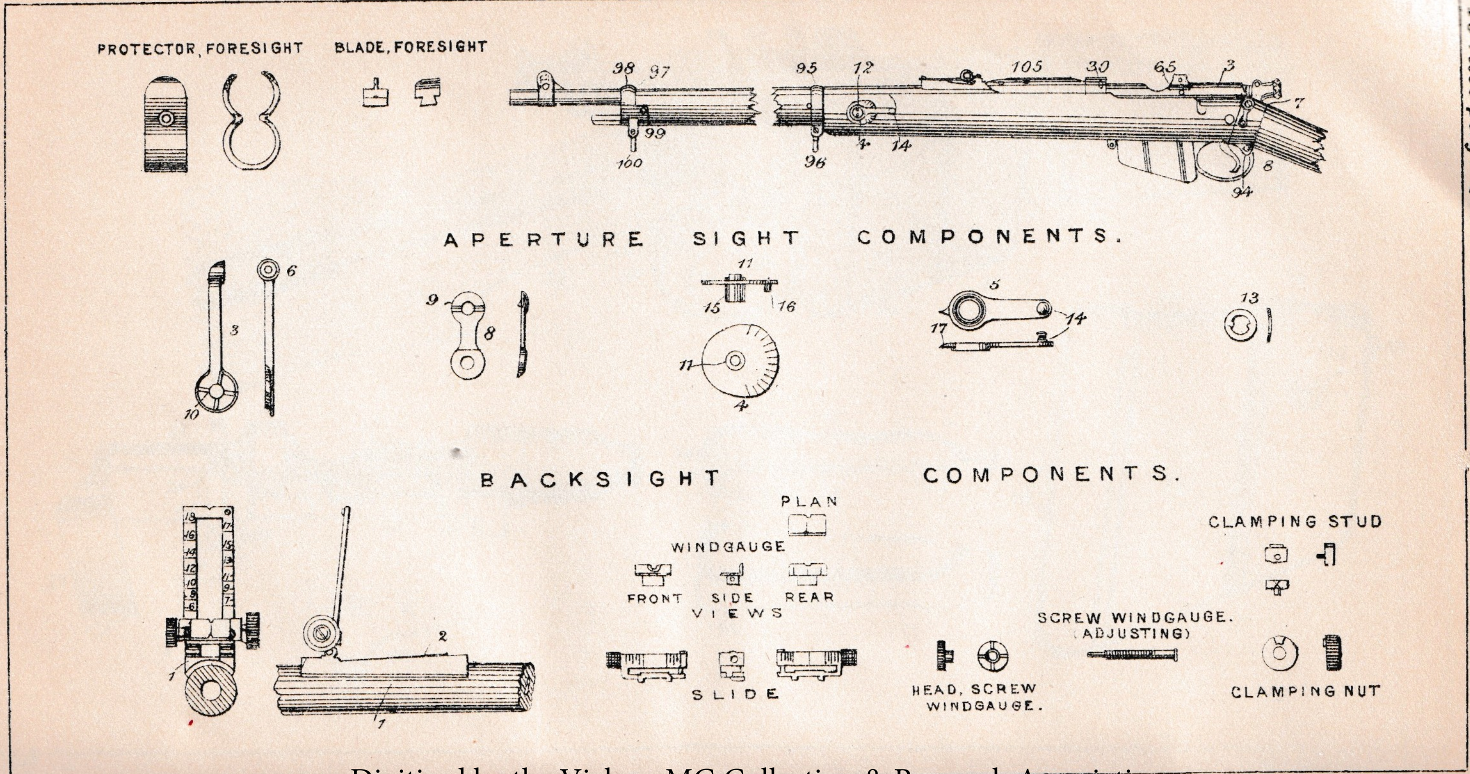
GREAT BRITAIN. CHARGER LOADING LEE-ENFIELD.

Plate XXIX.

To face page 61.



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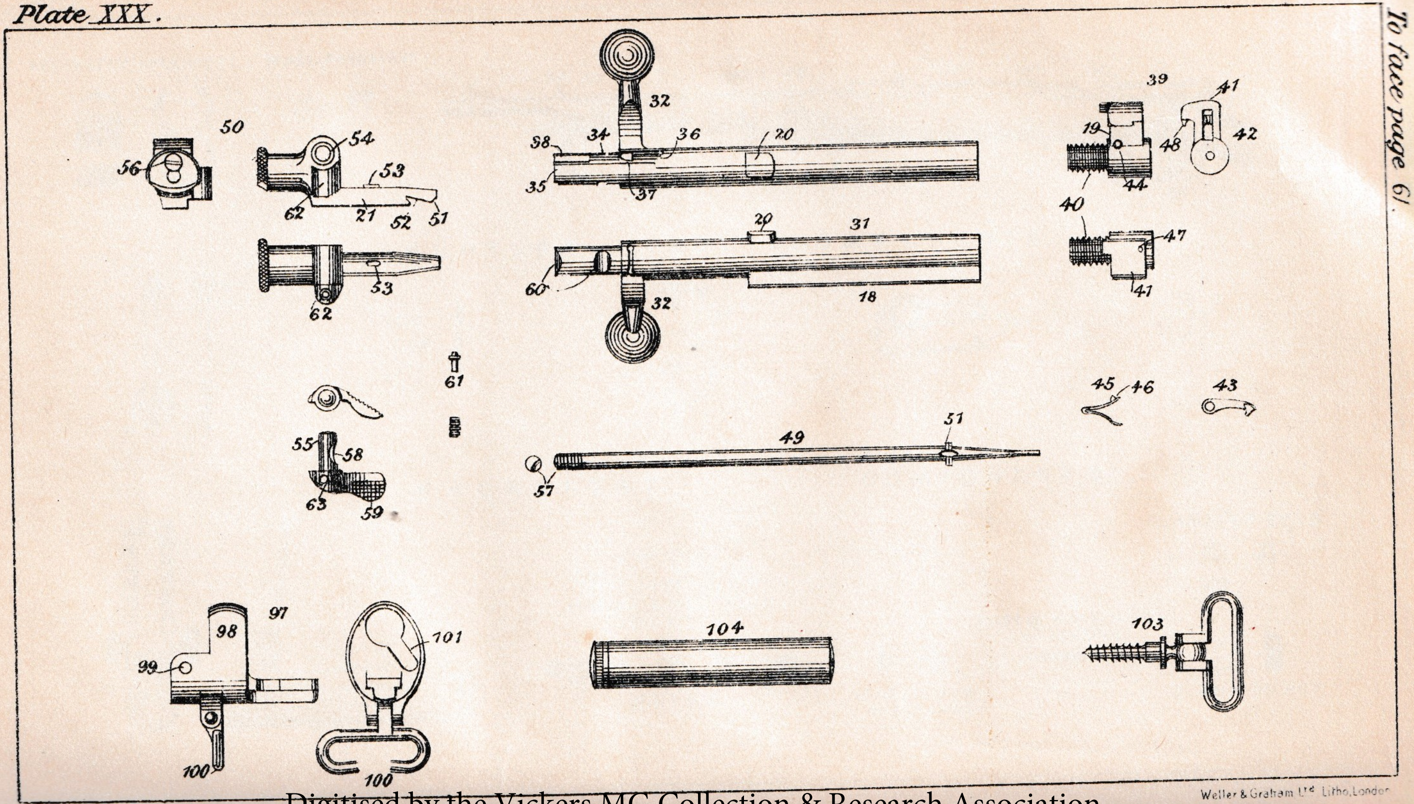
GREAT BRITAIN. CHARGER LOADING LEE-ENFIELD.

Plate XXX.

To face page 61.



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The rifles charger loading about to be described are of two patterns, converted from (*a*) rifles M.L.M., Mark II*, and (*b*) rifles M.L.E., Mark I, and Mark I*. See Table VII, Appendix.

The rifle charger loading M.L.E. will be described, and the differences in the rifle charger loading M.L.M. afterwards pointed out.

The barrel, which screws into the body, is strongly reinforced at the breech end, which is formed with a flat on its upper surface known as the "Knox form." This flat ensures the correct breeching up of barrel to body necessary to bring the sights vertical. The foresight block, with a long slope to the rear, is brazed on; the backsight bed is soldered on and secured by a screw. Barrel.

The foresight is a blade fitted into the block and laterally adjustable. It is provided with a protector fixed by a screw passing through the block. Sights.

The backsight bed (1) has a ramp (2) on either side, sloping upwards to the front just clear of the inside edges of the opening in the backsight leaf. The backsight leaf is hinged to the rear of the bed. Elevations for 200, 300, 400, and 500 yards are obtained with the leaf down; the position of the slide for these distances being marked on the left side of the bed. The leaf is graduated on alternate sides for ranges from 500 to 1,800 yards, to be obtained with the leaf up, the even numbers on the left, the intermediate 50 yards' graduation being indicated by short lines. The slide, which is provided with an adjustable wind-gauge having an adjusting screw on the left and a clamping nut on the right, has two U notches, for the horizontal and vertical position of the leaf, and platinum centre lines. The underside of the slide bears on the ramps of the bed when the leaf is down. Elevations from 1,600 to 2,800 yards are given by means of special long range sights; these consist of an aperture sight (3) attached to the left side of the body, and a dial sight (4) with pointer (5) attached to the left side of the fore-end. The aperture sight is a bar, terminating at the upper end in a flat button through which a peep-hole (6) is bored. It pivots on a screw (7) and is held in a raised or lowered position by the aperture sight spring (8), the lower end of which is screwed to the body, whilst the upper end presses on the end of the sight bar; a small rib (9) on the inner surface of the spring engages in one or other of the cross cut notches (10) on the sight bar. The pointer (5) pivots on a projection (11) on the dial, and is held in position by means of a screw (12); the curved spring disc (13) is placed under the head of the screw to enable the pointer to be held securely, and at the same time allow it to be moved easily. At the end of the pointer is a sharp edged bead (14). The dial sight fits in a recess in the stock, and is held in position by a screw passing through the fore-end into the projection (15). The pin (16) prevents the dial sight from

turning in its seating. To use the long range sights the point (17) of the pointer is set to the required graduation line; the aperture sight is raised and aim is taken through the peep-hole over the edge of the bead at the object.

The body. The sides of the body immediately in rear of the barrel seating broaden out underneath for the magazine, the usual opening being provided for inserting the cartridges into the magazine; the sides of the body do not form a complete circle over the rear end of the boltway, the body being slotted out to afford passage for the rib of the bolt (18) and for the extractor seating (19) of the bolt-head. Below the rear end of the boltway is a groove for the lug (20) on the bolt, and for the tongue (21) of the cocking piece. From the front end of this groove a recess (22) is cut in the left side of the body for the lug on the bolt. On the right side of the body is a rib (23); the rear end of this rib is cut away, and the head of the retaining catch (24) forms a continuation of it. Above the end of the rib is the resistance shoulder (25) for the rib on the bolt. Below the rib in the body and parallel with it is a slot (26) for the cut-off. At the end of the body, and forming part of it, a socket (27) projects downwards; into it the butt fits, and in the centre of it is a hollow threaded boss (28) for the stock bolt (29). Against the front face of this socket the rear face of the fore-end bears. Just in rear of the barrel seating, a gas escape hole (30) is cut through the left side of the body. A charger guide in the form of a bridge is riveted to the left and right side of the body in front of the resistance shoulder.

The bolt. The bolt (31) is cylindrical, and has a bent lever (32) near its rear end, terminating in a round knob. A solid rib (18) is formed on the right side. On the opposite side to the rib is a solid lug (20); this lug and rib support the bolt on firing. The back ends of the lug and rib are cut on a screw pitch, 14 threads to the inch, corresponding to the slope of the resisting shoulder (25) and the rear face of the lug seating (33) against which they bear. Underneath the rear end of the bolt is a recess formed by a long groove (34), and a short groove (35), connected together in front by a cam-shaped face (36) and separated by the studs (37) and (38).

Bolt-head. The bolt-head (39) has a tenon (40) which screws into the front of the bolt; the screw is right handed. A solid projection (41) on the bolt-head has a slot (42) cut in it for the extractor (43), which pivots on a screw (44), and is pressed down by a V-shaped spring (45), let into the slot above it; a small pin (46) on the end of this spring engages in a hole (47) in the top of the slot and is thus held in place. The extractor terminates in a claw which projects beyond the face of the bolt-head. A gas escape hole is provided in the left side of the bolt-head. The hook (48) on the right side of the solid projection engages the rib (23) on the body and prevents the bolt-head from turning.

The mainspring is of coiled wire, set to a length of $3\frac{1}{2}$ inches. The main-spring.

The striker (49) passes through the bolt, the rear end screwing into the cocking piece (50). It has a collar (51) against which the front of the mainspring bears. Striker.

The cocking piece (50) has a long tongue (21) projecting to the front and lying against the underside of the bolt; the front end of this tongue is the full bent (51), and the groove (52) across it forms the half bent. A stud (53) on the upper side of the tongue works in the two grooves (34) (35) in the underside of the bolt. The rear end of the cocking piece is cylindrical, and is bored out to fit over the rear end of the bolt. At right angles to this cylindrical portion a hole (54) is bored for the stem of the safety catch (55). The head of the screw (56) in the end of the cocking piece enters a recess (57) in the end of the striker, and prevents the latter from turning. The rear end of the cylindrical portion has a milled projecting rim to facilitate cocking the rifle. The cocking piece.

The safety catch is provided with a stem (55) which fits into the hole (54) in the cocking piece. This stem has a groove (58) cut in one side. When the finger piece (59) of the safety catch is raised, the stem (55) locks into one of the grooves (60) in the rear end of the bolt, and thus prevents the cocking piece and striker from moving whether in the cocked or fired positions, but when the finger piece is turned down the groove (58) in the stem allows the cocking piece to pass over the end of the bolt. The finger piece is roughed above and below to afford a firm grip. The safety catch is held in the safety and firing positions by a small plunger (61) actuated by a spiral spring, both of which fit into the projection (62) on the cocking piece. A nipple on the end of this plunger engages in one or other of the two holes (63) in the safety catch according to its position. Safety catch.

The retaining catch (64) is a flat spring secured by a screw to the right side of the body. The spring stands out slightly from the body, and has a projecting edge which forms a continuation of the rib (23) on the body. To remove the bolt, it must be drawn back as far as possible, and the bolt-head pressed upwards to force the hook (48) over the edge of the spring; the projection on the bolt-head can then be turned upright, and in this position will pass through the slot between the sides of the body. Retaining catch.

The ejector (65) is a small screw in the left side of the body. Its end projects into the boltway, and, on drawing back the bolt, catches the back edge of the cartridge case, swinging it round to the right clear of the rifle. Ejector.

The sear (66), in the form of a bell crank lever, is pivoted underneath the body on the screw (67) that holds the retaining catch. It works in a groove in the projection (68), and is actuated by a U-shaped spring (69) which also works the magazine catch. The long arm of the sear projects through a Sear.

slot in the body into the groove for the cocking piece. A short arm projects downwards, and is connected with the trigger by a knuckle joint.

Trigger.

The trigger (70) works in a slot in the trigger guard, and is pivoted on the pin (71); it is connected with the sear as described above.

Magazine.

The magazine contains 10 cartridges in two columns. It consists of a detachable sheet-steel box (72) with two flutings on either side, which serve as guides to the projections (73), (74), on the platform. It is provided with a magazine stop clip (75), which is pivoted to the stud (76) on the right side of the magazine. When the clip is vertical the top edge, which is bent inwards, keeps the bullet of the top cartridge in the right-hand column in position; it also keeps the platform (77) in the magazine when the latter is empty. When the clip is swung to the front, the platform and spring can be taken out for cleaning, the magazine having first been withdrawn from the body. A small projection (78) on the magazine casing prevents the clip being turned too far back. On the back of the magazine is a rib, in which is cut a tooth (79) which, when the magazine is pressed up through the opening in the trigger guard, against the underside of the body, engages with the tooth (80) of the magazine catch (81). This catch is pivoted on a pin to the projection (68) under the body and is pressed forward by the sear spring (69). To take the magazine out of the rifle, the end (82) of the catch must be pressed backwards and upwards.

Magazine platform.

The magazine platform (77) is formed of sheet steel; the left side is higher than the right, in order to raise the left column of cartridges, so that the centres of the cartridges in one column are opposite to the edges of the cartridges in the other column. The right rear corner (74) is turned upwards to act as a guide. Underneath is brazed a plate (83), from three corners of which small tongues (73) project downwards to act as guides. Two tongues (84) on each side are turned inwards to secure the magazine spring (85) which is of ribbon steel bent into a zig-zag form. The magazine platform auxiliary spring (86) is hooked on to the front end of the magazine, and serves to keep the front end of the platform at the proper angle when the magazine is full of cartridges, and also to protect the front of the magazine from being indented by the points of the bullets.

Cut-off.

The cut-off (87) is pivoted to a vertical screw in the projection (88) on the right side of the body. It works in a slot parallel to and below the rib for the bolt-head hook. It is provided with a thumb piece (89) for drawing it in and out. It is spring tempered and set so as to press upward. The small projecting flat (90) on it acts as a catch against the side of the body, and holds the cut-off open or closed; in the latter position it keeps down the cartridges in the magazine out of the path of the bolt, and serves as a platform for single loading. When the

cut-off is pulled out, the top cartridge in the magazine bears against the under face of the body, with its rim projecting into the boltway. The bolt, in advancing, forces it into the chamber, and the top cartridge of the other column rises into position for loading next time. When the magazine is empty, it is loaded by inserting a charger in the charger guide and pressing down the cartridges with the thumb, five at a time.

Guard. The guard (91) is attached to the body by a screw (92) passing up through a collar (93) let into the fore-end, and by a small transverse screw (94) passing through ears on the bottom of the socket of the body.

Stock. The stock is in two pieces. The fore-end is held to the barrel by a lower band (95), which carries a sling swivel (96), and by the nose-cap (97), a band (98) forming part of which passes over the barrel. The nose-cap is secured to the fore-end by a transverse screw (99). A sword bar is formed in front, which fits into the pommel of the sword bayonet. Underneath the nose-cap the piling swivel (100) is pivoted on a screw. A diagonal slot (101) is cut through the front end of the nose-cap to afford a passage for the foresight block.

Butt. The butt, which has a pistol grip, has its front end compressed and forced into the socket of the body. It is secured by the stock bolt (29) the front end of which is squared and, passing through the front face of the socket, fits into a square recess in a keeper plate (102) let into the fore-end. The stock bolt is thus prevented from turning until the fore-end is removed. The butt plate is of yellow metal, the heel being turned over, forming a tongue, in the top of the butt. It has a hole in it, closed by a trap operated by a spring, and is secured to the butt by three screws. The butt swivel (103) is screwed into the underside of the butt.

Butts $\frac{1}{2}$ inch shorter and $\frac{1}{2}$ inch longer than the normal are issued as required.

Action of the bolt mechanism. On raising the bolt lever, the cocking piece is prevented from turning with the bolt, owing to the tongue (21) working in the groove in the body. The bolt-head is also prevented from turning by the hook (48), which engages the rib (23) on the body; as the bolt lever rises, the cam-shaped face (36) on the underside of the bolt forces back the stud (53) on the tongue of the cocking piece. This draws the end of the striker clear of the face of the bolt-head, and partly compresses the mainspring. As the bolt lever is turned up, the front sloping face of the bolt lug (20), working against the front face of the recess (22) in the body, causes the whole bolt to move to the rear, drawing back the fired case with it, and thereby effecting primary extraction. When the bolt has been turned round as far as it will go, that is until the rib (18) touches the left side of the body, the rib is opposite the gap between the sides of the body and the lug (20) is in the groove for the cocking piece; the bolt is then free to be drawn back,

until the projection on the bolt-head strikes against the resisting shoulder (25). The stud (53) on the cocking piece has then fallen into a recess in the front end of the short groove (35) of the bolt, and the cocking piece is retained in the position for entering the cocking-piece groove. On pushing forward the bolt, the full bent of the cocking piece engages the end of the sear, and the mainspring is further compressed, the stud (53) on the cocking piece passing the stud (37) in the bolt. On turning down the bolt lever, the bolt is forced forward by the sloping faces on the rear of the lug (20) and rib (18). This completes the compression of the mainspring. The stud (53) is now in the long groove in the bolt, and, on pressing the trigger, the sear is depressed and disengaged from the cocking piece which flies forward, and the striker fires the cartridge. If the bolt is not completely closed when the trigger is pressed, the stud (53) on the cocking piece either causes the bolt to close automatically by striking against the rounded corner of the stud (37) between the grooves in the bolt, and thus causing the bolt to turn down, or else the stud (53) strikes full against the stud (37) and prevents the striker flying forward. If then the bolt is closed by hand the sear engages in the half bent (52) and the action is locked owing to the two studs (53, 37) being side by side, thus preventing the rotation of the bolt.

Charger. The charger is of steel, oil-blacked. Holes are punched in the sides and back for lightness. The sides extend some distance along the cartridges, to prevent the latter from getting out of line while being pressed into the magazine. Each charger holds five cartridges. (See Plate LXI.)

Oil bottle. In a hole in the butt in the rear of the stock bolt is carried a brass oil bottle (104) with a screw top, a leather wad being inserted between the oil bottle and stock bolt. On the top of the oil bottle is carried a cord pull-through for cleaning the rifle, its brass weight being carried in a small hole above the stock-bolt hole.

Handguard. The wooden handguard (105) is attached by two spring clips to the barrel. It extends from the face of the body to the backsight bed, and has its front corners rounded off to facilitate removal.

Bayonet. The sword bayonet, pattern 1888, Mark III, is double-edged, the blade being 12 inches long. The pommel and crosspiece are browned. The grips are removable to facilitate re-browning, and are secured by two screws and nuts. The bayonet is attached to the sword bar of the nose-cap by the usual spring catch, the ring on the crosspiece fitting over the end of the barrel.

Scabbard. The latest pattern scabbard for the above bayonet is pattern 1903 of brown leather. The bottom is closed by a steel chape, which is fitted inside the end of the scabbard. The steel locket is browned, and has two flat springs inside, which bear against the blade of the bayonet, and prevent it from

Plate XXXI. GREAT BRITAIN, SHORT RIFLE, MAGAZINE LEE-ENFIELD (MARK III)

To face page 67.

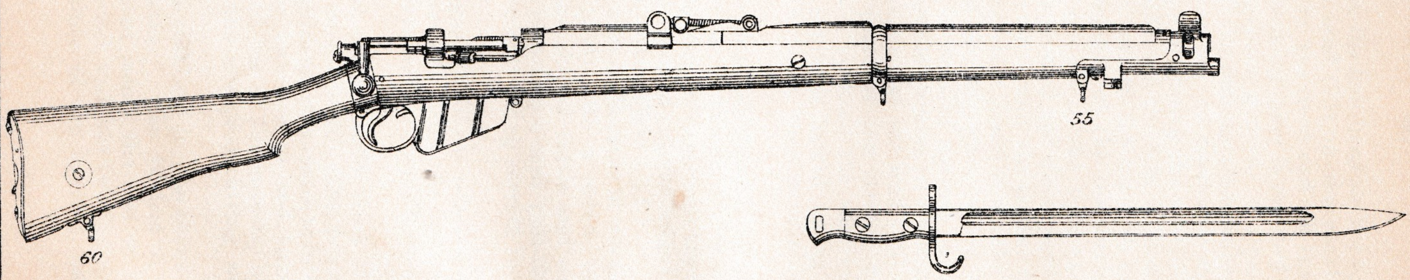

Plate XXXII.

GREAT BRITAIN, SHORT RIFLE, MAGAZINE LEE-ENFIELD (MARK III)

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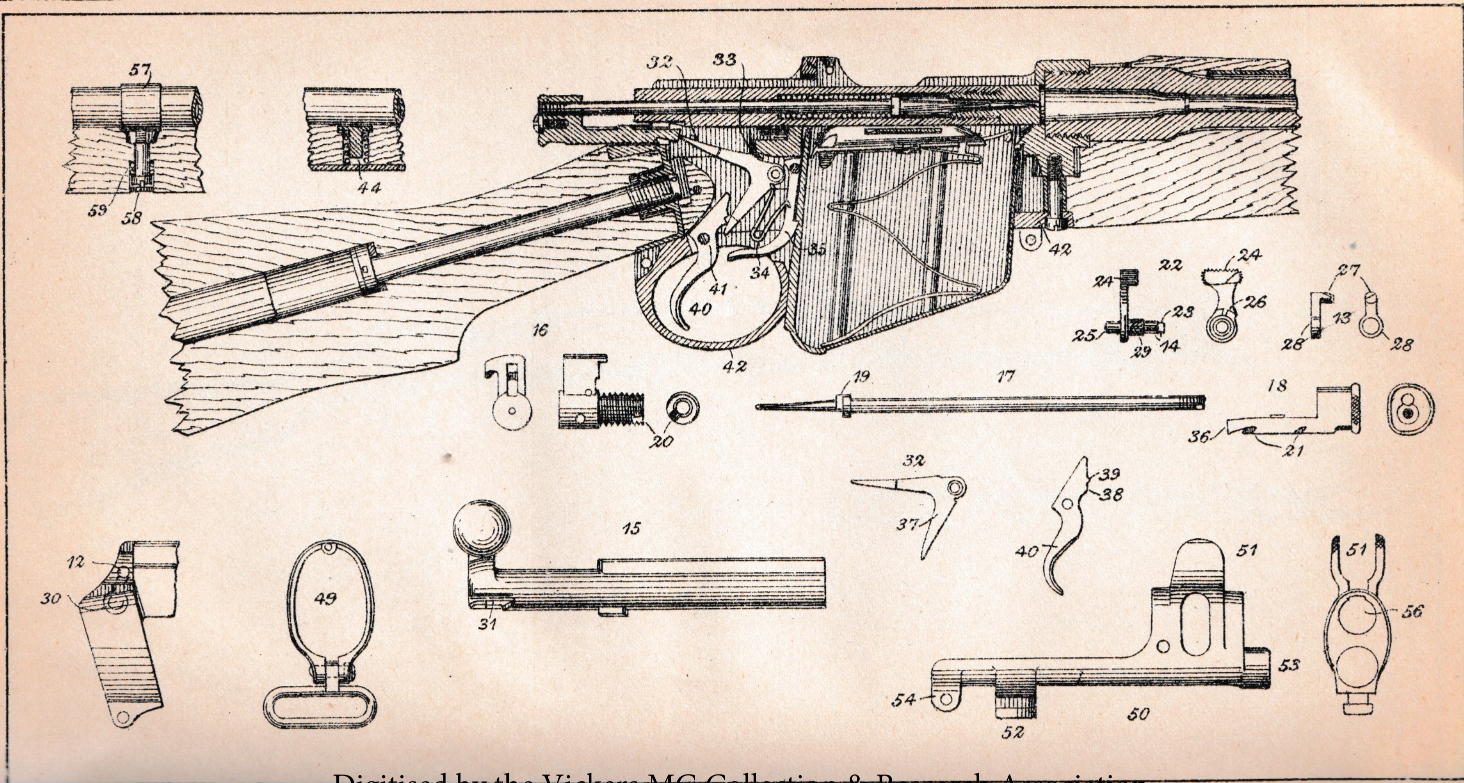

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Plate XXXIII. GREAT BRITAIN, SHORT RIFLE, MAGAZINE LEE-ENFIELD (MARK III)

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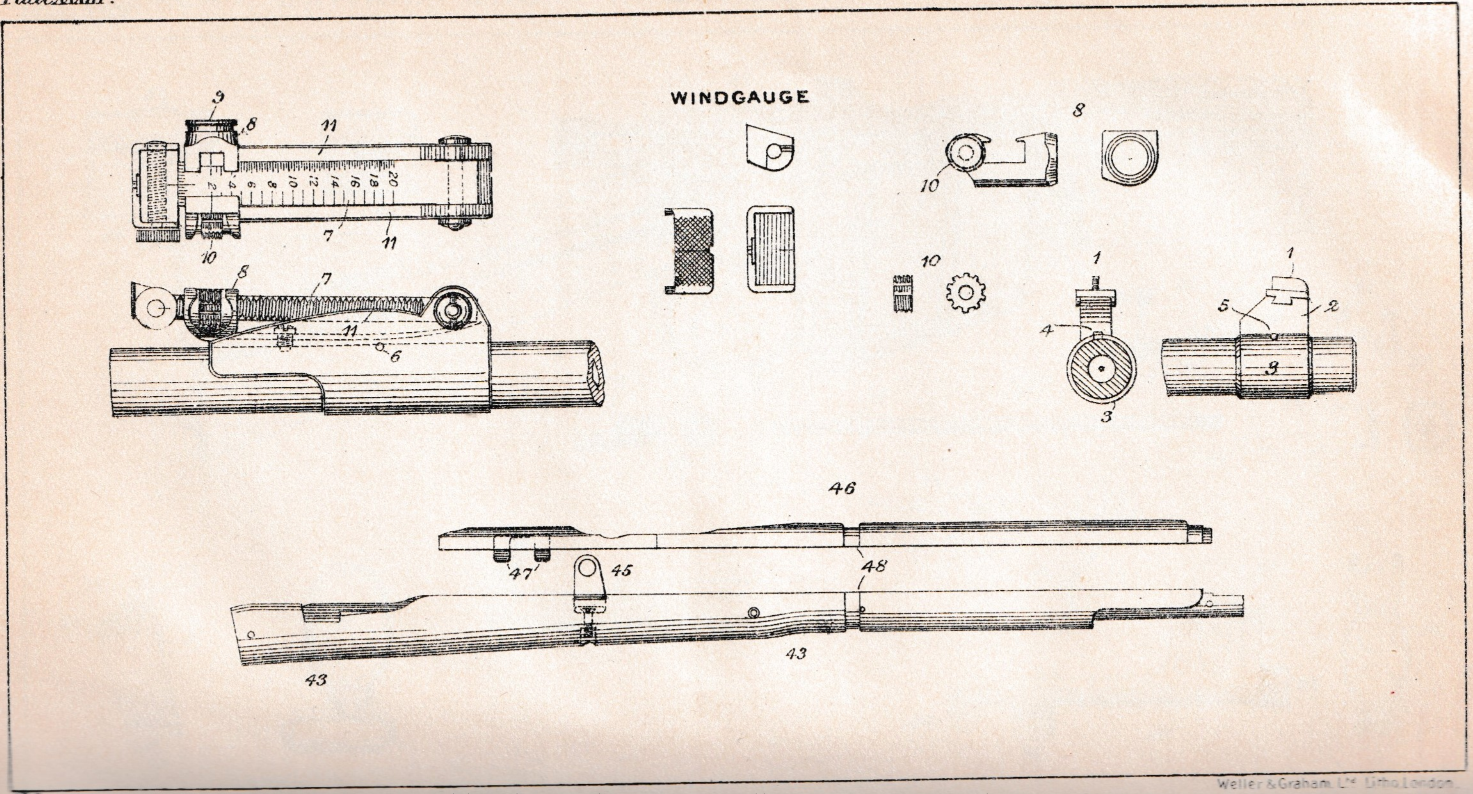

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falling out. The locket is covered with a leather band tightly sewn on and secured by a wire rivet. Forming part of this band is a leather loop, by which the scabbard is suspended from the waist belt.

For weights and dimensions see Table IV, the Appendix.

Short Lee-Enfield, Mark III, 7·7 mm., ·303-inch, Pattern 1907. See Tables V and VI, Appendix.

The barrel, which screws into the body, is rather thinner, and is 5 inches shorter than that of the Lee-Enfield rifle. It is strongly reinforced at the breech end, and is provided with a "Knox form," as in the Charger loading rifle. The grooves of this rifle are of the same shape as the Enfield rifling, and increase in depth towards the muzzle. **Barrel.**

The foresight consists of a plate (1) dovetailed into the foresight block (2) at right angles to the axis of the barrel, so that it is capable of lateral adjustment. The foresight block is formed with a band (3) which fits the barrel; it is kept in position by a key (4) and crosspin (5); it is set ·015″ left to counteract the lateral vibrations of the barrel set up on firing. The backsight bed encircles the barrel, to which it is attached by a crosspin (6) in the middle, being also supported by the sight spring screw. The leaf (7) which is made to turn over on to the handguard and rebound, is graduated on the top left side by lines representing every 25 yards between 200 and 2,000 yards, and on the top right side by lines representing hundreds of yards. The slide (8) may be set at any elevation, above or below the elevation at which it was last set, in multiples of 50 yards, by pressing the catch (9) on the left side and releasing a fine-adjustment worm wheel (10) engaged in screw thread notches on the right side of the leaf, thus enabling the slide to be moved quickly along the leaf. The worm wheel is pivoted in the right side of the catch, and may be rotated in either direction at right angles to the leaf, this movement providing fine adjustment for the slide. The periphery of the worm wheel is divided by 10 thumbnail notches, the distance between each notch representing 5 yards in range, *i.e.*, 5 notches 25 yards, or one division on the left side of the leaf, and one complete revolution 50 yards. **Sights.**

A windgauge is fitted directly on the rear end of the leaf, and is held in position by the windgauge screw. A U-shaped notch is cut in the top edge and the face is roughened to prevent the reflection of light from it. Bright centre lines are marked on the face of the windgauge for aiming, and on the top as a centre line for use in conjunction with the windgauge scale on the leaf. The windgauge scale is marked in divisions representing 6 inches deviation on the target at 100 yards. Each quarter-turn of the windgauge screw represents 1 inch deviation at 100 yards, and at each quarter-turn a friction spring engages in a nick inside the head of the screw, thus checking its rotation.

Between the ramps is a flat backsight spring which is dovetailed and screwed at its rear end to the bed; its front end presses upwards against the leaf in front of the joint, so that the slide (8) is always pressed down on to the ramps (11).

The long range sights are identical with those described for the Charger loading rifle.

Body. The body is similar to that of the Charger loading rifle with the exception that a hole (12) is bored through the left side of the body, near the rear, for the safety catch (13), and below it another hole for the stem of the locking bolt (14) leads into the cocking-piece groove.

Bolt. The bolt (15) is similar to that of the rifle C.L.M.L.E., except that it is without the extension at the rear end, necessitated by having the safety catch on the cocking-piece.

Bolt-head. The bolt-head (16) is similar to that of the Charger loading rifle.

Mainspring. The mainspring consists of coiled wire, set to a length of $3\frac{1}{2}$ inches.

Striker. The striker (17) passes through the bolt; its rear end screws into the cocking piece (18). It has a collar near its front end for the mainspring to bear against. In front of this collar is a small projection (19) which fits into the recess (20) in the rear end of the bolt-head tenon.

Cocking piece. The cocking piece (18) is similar to that of the rifle Charger loading M.L.E., with the exception that the projections for the safety catch are omitted, and also the hollow sleeve which is fitted over the rear end of the Charger loading M.L.E. bolt. The bolt is stripped (having first removed the striker keeper screw) by unscrewing the bolt-head, when a recess (20) in the latter engages a projection (19) on the striker and unscrews it at the same time. The two recesses (21) on the left side of the cocking piece are for the locking bolt to engage in.

Locking bolt. The locking bolt (22) is provided with a stem (14) which fits into a hole in the left of the body leading into the groove for the cocking piece. The end of the stem is cut away at (23), so that when the roughened thumb piece (24) is in the forward position, the cocking piece passes over the end of the stem, where it is cut away, but when the thumb piece is drawn to the rear, the solid portion of the end of the stem engages in the back or front recess (21) of the cocking piece, according to whether the latter is in the fired or cocked position, and locks it securely. When the end of the stem (23) engages in the front recess (21) it draws the cocking piece back slightly. The aperture sight fits on to the stem (25), and the head of the aperture sight spring, which is similar to that of the Charger loading rifle, keeps all the parts in position. The small hole (26), on the inner face of the locking bolt, has two stop-pins provided for it on the exterior of the body, on to one or other of which it drops, according to the position of the locking bolt.

The locking bolt safety catch (13) is formed with a stem (27) which fits in the hole (12) in the left side of the body. At right angles to the outer end of this stem is a flat arm (28), the bottom of which works on the threads (29) on the locking bolt. When the thumb piece (24) is in the forward position, the end of the stem (23) is inside the hole (30) in the body, but when the thumb piece is turned over to the rear, the threads (29), acting on the end of the arm (28), force the safety catch inwards, and the end of the stem (27) enters the short groove (31) in the rear end of the bolt, and prevents the latter from being rotated and drawn back. Locking bolt safety catch.

The retaining catch is a flat spring similar in all respects to that described for the Charger loading rifle. Retaining catch.

The ejector is identical with that described for the Charger loading rifle. Ejector.

The sear (32) is pivoted in a groove in the projection (33) beneath the body on the same screw that fixes the retaining catch. It is pressed to the rear and upwards by the U-shaped spring (34) which also actuates the magazine catch (35). The long arm of the sear passes through an opening in the body into the groove for the cocking piece, and engages with the full bent (36) of the latter when the bolt is pushed forward. The short arm (37) projects downwards, and is pressed forward by the ribs (38, 39) on the trigger when the rifle is fired. Sear.

The trigger (40) is pivoted on the pin (41) which passes through the trigger guard. The upper part of the trigger is formed with two ribs (38) and (39), the former being nearest the pivot. On pressing the trigger, the rib (38) first comes in contact with the sear, and forces the latter to revolve on its axis until the end of the long arm of the sear comes close to the edge of the bent (36) on the cocking piece. The pull on the trigger during this movement has been light, as the rib (38) is close to the pivot, and great leverage is obtained. The rib (39) then acts on the sear, and a greater pressure on the trigger is necessary, on account of the rib being further from the pivot; its motion, however, is more rapid, so that the end of the sear is drawn smartly off the bent of the cocking piece. This principle of a double pull-off is used with all Continental rifles. Trigger.

The action of the bolt mechanism is exactly the same as that described for the Charger loading rifle. Action of the bolt mechanism.

The magazine is the same as that for the Charger loading rifle. Magazine.

The trigger guard (42) is similar to that of the Charger loading rifle with the exception of the addition of swivel lugs in front of the magazine. Guard.

The fore-end and butt are similar to those described for the Charger loading rifle. The fore-end (43) is a close fit on the body and the barrel up to the backsight; from the backsight to the muzzle, the barrel groove is opened out, the muzzle being free in the groove. Stock and handguard.

The barrel groove is deepened so as not to touch the bottom of the barrel from the reinforce to within $\frac{1}{2}$ inch of the lower band; from the lower band the bottom of the barrel groove is flush with the barrel hole in the nose-cap. Behind the nose-cap the fore-end is recessed at the bottom of the barrel groove to receive a stud and spring (44).

A backsight protector (45) of steel, oil blacked, is let into the fore-end, and secured by a vertical screw with nut. It is provided with two upstanding ears, roughened on top so as not to reflect the light. These ears protect the backsight from injury when the rifle is let fall, and from contact with the bucket when carried by cavalry.

The handguard (46) extends the full length of the barrel. It is divided into two parts by a sawcut opposite the backsight bed. The handguard spring (47) is riveted on with two rivets, and clips on to the barrel near the breech end. The front end of the handguard is strengthened by a sheet steel cap, secured by two screws, and fits under a recess in the nose-cap. A groove (48) is cut for the jointed lower band (49), a slot being formed to give clearance for the hinge. The handguard does not touch the barrel, as the barrel groove is of greater diameter than the barrel. The nose-cap (50) is much larger than that of the Charger loading rifle. It is provided with high wings (51) roughened on top, to protect the foresight. Underneath is a sword bar (52) for the attachment of the pommel of the bayonet, and in front is a boss (53) on to which the ring of the sword bayonet crosspiece fits. The sword bayonet is thus fixed underneath the rifle to the nose-cap only, and does not touch the barrel. At the rear end is a swivel seating (54) in which the piling swivel (55) is fixed. The barrel hole (56) in the nose-cap has a groove cut in the top, against the corners of which the barrel is pressed by the fore-end stud and spring. An inner band (57) is permanently carried on the barrel; it is grooved out so as to touch the barrel in two places. This band is fixed in the barrel groove of the fore-end in rear of the lower band, by means of the screw (58), the head of which bears against a strong spiral spring (59). The inner band draws the barrel down on to that portion of the barrel groove in the fore-end that is not eased away.

Butt.

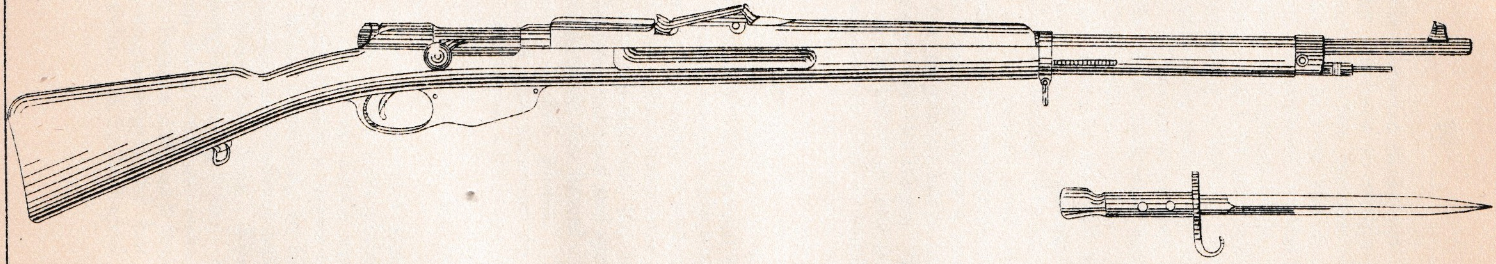
The butt is provided with a shorter stock bolt than that of the Charger loading rifle. The butt plate is of brass with a trap for the insertion of the oil bottle and pull-through. A brass marking disc is fixed with a screw to the right side. A sling swivel (60) is fitted (screwed) to the underside of the butt. The butt has four longitudinal holes drilled in it for lightness, besides the stock bolt hole. The front end is compressed, as in the Charger loading rifle. Butts $\frac{1}{2}$ inch shorter and $\frac{1}{2}$ inch longer than the normal are issued as required.

Bayonet.

The sword bayonet Pattern 1907 is 5 inches longer than the Pattern 1888. It is single edged and has a fuller (or lightening groove) on both sides. A hook-shaped guard is formed on the crosspiece.

HOLLAND. MANNLICHER 1895.

To face page 71.



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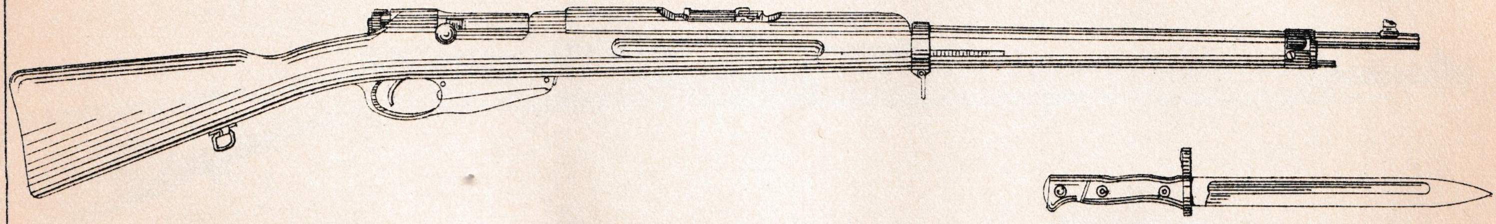
ROUMANIA. MANNLICHER 1893.

Plate XXXV.

To face page 71.



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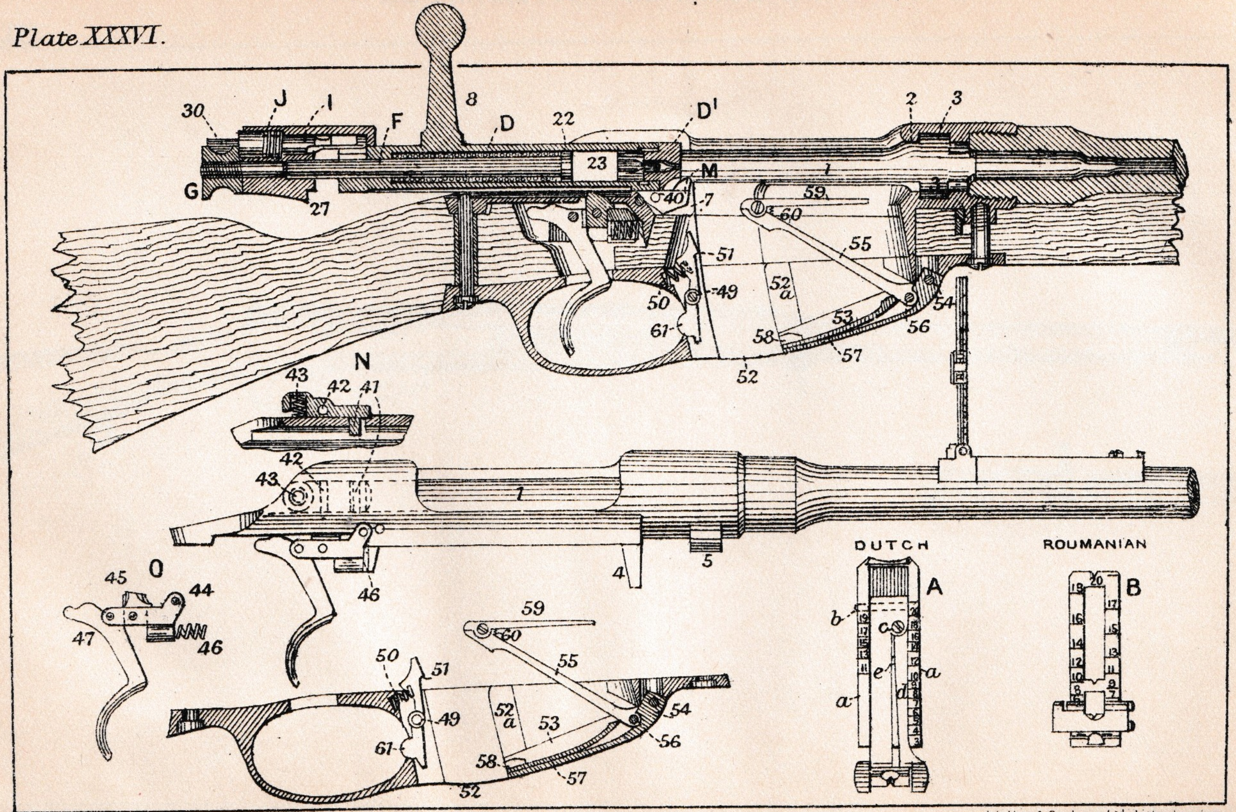
HOLLAND AND ROUMANIA.

Plate XXXVI.

To face page 71.



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HOLLAND AND ROUMANIA

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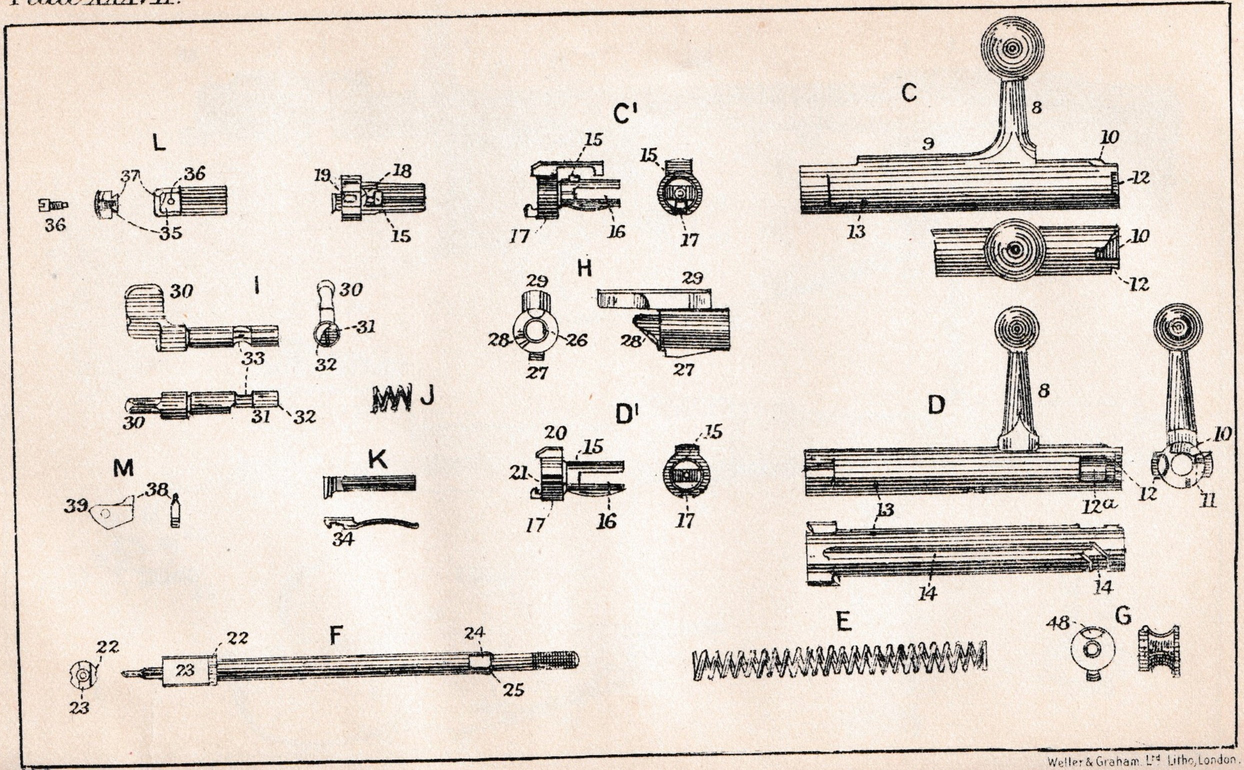


The scabbard is made of a shape and length suitable for the blade of the sword bayonet. A stud is fitted and brazed on to the locket for fastening the scabbard in the web frog which is hung on the waist-belt. Scabbard.

For weights and dimensions see Table IV, Appendix.

CANADA.

Ross Rifle, Mark II, ·303-inch, 1907.

A description of this rifle will be found in Appendix II., page 259.

GREECE.

Mannlicher-Schoenauer, 6·5 *mm.,* ·256-*inch, Pattern* 1903.
See page 77.

HOLLAND.

Mannlicher, 6·5 *m.m.,* ·256-*inch, Pattern* 1895.

ROUMANIA.

Mannlicher, 6·5 *m.m.,* ·256-*inch, Pattern* 1893.

These two Mannlicher rifles have not got straight pull bolts like the Austrian Mannlichers, but have the more usual rotating bolt, with locking lugs near the front end. The two rifles are of very similar construction, with the exception of their ejectors, backsights and handguards. The Roumanian pattern is the handier, as it is $2\frac{1}{2}$ inches shorter and $14\frac{1}{2}$ oz. lighter.

The barrel which is polished and browned on the outside tapers from the reinforce to the muzzle. It screws into the body in the usual manner. Barrel.

The foresight block is brazed to the barrel, and the barley-corn, the tip of which is rounded off in the Roumanian rifle, is dovetailed into it at right angles to the axis of the barrel. The backsight bed is soldered and screwed to the barrel. In the Dutch pattern the bed A is broader than the barrel, and is similar in principle to that on the Austrian Mannlicher Pattern 1888/90. The high sides (*a a*) form a protection for the leaf which is pivoted at (*b*) near the front end. On the right side of the leaf at (*c*) a bar (*d*) is pivoted by means of a screw. The bar (*d*) is pressed outwards by the spiral spring (*e*); the outer edge of the bar, which is bevelled off at an acute angle, fixes the sight at any required graduation, by entering into the grooves which radiate from the pivot (*b*), on the inner face of the right side of the bed. The elevation can be altered by grasping the rear end of the leaf with the finger and thumb, thus disengaging the edge of the bar from the grooves and permitting of the leaf being raised or lowered. There is one V which is cut in the cap Sights.

at the rear end of the leaf. The graduations from 400 to 2,000 metres are marked on the top face of the right side of the bed. Up to 1,000 metres each 100 is shown, between 1,000 and 2,000 the even hundreds only are marked on the right side of the bed, the odd numbers being marked on the left. With the sight in the lowest position 200 metres elevation is obtained. See Fig. 9, page 108.

In the Roumanian pattern the backsight B is similar to the Austrian Mannlicher Pattern 1895, but the leaf has a peculiar bar across it which coincides with the slide when it is at 1,200 metres elevation. It completely obstructs the aim when the slide is fixed at 1,100 metres. The fixed sight with leaf down is for 500 metres. Elevations from 600 to 1,900 metres are marked on the leaf, the even hundreds on the left; 2,000 metres elevation is obtained by aiming over the top of the leaf.

Body. The body screws on to the barrel in the usual manner. On either side of the boltway is a longitudinal groove (1, 1) for the lugs on either side of the front end of the bolt. At the front end of these grooves are cam-shaped grooves (2, 2) which lead to the recesses (3, 3) above and below the boltway. On firing, the lugs resist the backward pressure of the cartridge case by taking a bearing against the rear face of the recesses (3, 3). The groove (1) on the right is partly cut away to facilitate loading the magazine and to permit of ejection of the fired cartridge. Behind the recesses (3, 3) the bottom of the body is cut away for the magazine. Behind the magazine way the body does not form a complete cylinder, but is cut away at the top to permit of the passage of the bolt lever (8). The rear part of the body forms a tang in which a groove is cut for the stud (27) of the cocking piece. Near the front end of this groove is an opening through which the bent of the sear (45) projects. At the front end of the magazine way is a projection (4), the rear face of which is grooved to form a guide for the bullets of the cartridges as they rise in the magazine, it also serves to keep the trigger guard at the correct distance from the body. Underneath the front part of the body is a boss (5) which fits in a recess in the stock and transfers the shock of recoil from the barrel and body to the stock. It also takes the front guard screw. In the Roumanian rifle there is a narrow slot (7) just in rear of the magazine way for the ejector to work in.

Bolt. The bolt can be stripped and assembled without the use of tools. At the front end are two lugs on opposite sides of the bolt. The bolt lever (8) projects at right angles to the bolt, about one-third of its length from the rear, and terminates in a knob. It turns down into the opening cut away on the right side of the body. C represents the Dutch, and D the Roumanian bolt; the former has a strengthening rib (9) in line with the lever. Both bolts have a cam-shaped recess (10) at the rear end, into which the tooth (28) of the cocking piece, H, enters on firing. On turning up the bolt lever to draw back the bolt, the tooth of

the cocking piece rests in the shallow groove (11). A segmental recess (12) on the rear end of the bolt receives the end of the safety bolt; it is larger in the Roumanian than in the Dutch pattern. A small hole (13) is provided for the escape of any gas that may enter the bolt, on account of a defective cartridge or cap. The groove (14) in the Roumanian bolt provides a clearance for the ejector used in that arm. The bolt is bored out from the front for the striker and mainspring, the former of which passes out through a hole in the rear end of the bolt.

Bolt-head. The bolt-heads C_1 and D_1, for the above bolts, are provided with tenons which fit into the front ends of the bolts. The studs (15) work in circular grooves on the inside of the bolts. The bolt-heads can only be withdrawn when the studs are turned, so that they are opposite clearances provided for them. The tenons are slotted at (16) for the flats on the front of the strikers. The extractor (K) fits into a groove (17) in the side of the bolt-head. In the Dutch pattern, C_1, a stud (35) on the ejector, L, fits into an undercut groove (18). In the Roumanian pattern, D_1, a projection (20) occupies the position of the ejector in the Dutch model. This projection (20) and the ejector L work in the left hand groove (1) in the body and prevent the bolt-head from rotating.

The slot (21) in the bolt-head D_1, allows the point (38) of the ejector M to get behind the base of the cartridge.

Mainspring. The mainspring E consists of 26 coils of ·056 wire. The rear end bears against a seating in the bolt cylinder.

Striker. The striker, F, passes through the mainspring, bolt, and cocking piece, and screws into the nut G. The front end of the mainspring bears against the collar (22). The flat (23) works in the slot (16) in the bolt-head and prevents the cocking piece from turning when the stud (27) is clear of the groove in the tang, the bolt being drawn to the rear.

Cocking piece. The cocking piece, H, fits on to the striker and butts up against the shoulder (25) on it. It is prevented from turning by the end of the screw (26) bearing on the flat (24) on the striker. The stud (27) travels in the groove in the tang of the body and engages with the bent of the sear (45). The action of the tooth (28) will be described under the heading "Action of the Bolt Mechanism." The rib (29) is bored out from the rear for the stem of the safety bolt.

Safety bolt. The stem of the safety bolt, I, fits in its seating in the rib (29) of the cocking piece. It is operated by means of the finger piece (30). A small spiral spring, J, fits over the stem and keeps the safety bolt pressed to the rear. When the striker is cocked, and the finger piece is pointing to the left, the stem of the safety bolt is able to move forward over the bolt, as the half that is cut away (31) is underneath, next to the bolt. When the finger piece is turned over to the right, the small cam (32) on the end of the safety bolt engages the front of the recess (12) in the bolt and forces safety bolt and cocking

piece back, disengaging the stud on the latter from the sear bent. The safety bolt and cocking piece cannot now move forward when the trigger is pressed, as the end of the former is engaged in the recess (12). In the Roumanian pattern the finger piece can be turned over to the right, and the bolt locked, when the cocking piece is in the fired position. The end of the stem of the safety bolt then engages in the recess (12*a*), a clearance (33) being provided in the stem for the division between the recesses (12, and 12*a*). In the Dutch pattern the bolt cannot be locked in the fired position.

Extractor.

The extractor, K, fits in the groove (17) in the bolt-head. The shoulder (34) fits against a corresponding shoulder in the bolt-head, and takes the strain during extraction. The front terminates in the usual claw.

Ejector.

In the Dutch pattern the undercut stud (35) on the ejector, L, slides backwards and forwards in the undercut groove (18) in the bolt-head, its travel being limited by the screw (36) working in the groove (19). The back of the ejector strikes the retaining bolt when the bolt and bolt-head are drawn to the rear. The ejector slides forward, and the front of the stud (35) strikes the left rear of the cartridge, ejecting it to the right. The front edge of the stud is bevelled off at (37) to enable the base of the top cartridge to push back the ejector as it rises out of the magazine. In the Roumanian rifle the ejector, M, is pivoted on a pin (40) in the slot (7) in the body, with the tooth (38) to the front. The tail (39) works in the groove (14) in the bolt; when it arrives at the front end of the groove it is depressed, and the tooth (38) being raised into the slot (21) in the bolt-head, strikes the base of the cartridge, and tilts it out of the rifle.

Retaining bolt.

The retaining bolt, N, is pivoted on a vertical pin (42) on the left side of the body near its rear end. The tooth (41) projects into the groove (1) in the body and arrests the backward movement of the left lug. In the Dutch rifle it is the ejector that strikes the tooth (41). The small spiral spring (43) keeps the tooth up to its work. To take the bolt out, the tooth (41) may be withdrawn by pressing on the thumb piece on the rear end of the retaining bolt.

Sear.

The sear, O, is pivoted underneath the body on a pin (44) behind the magazine way. The bent (45) projects through a slot into the groove in the tang; it is pressed upwards by the spiral spring (46) which bears against a projection underneath the body.

Trigger.

The trigger works in a fork in the rear end of the sear, and pivots on the pin (47). It has two ribs on its top end, which bear alternately against the underside of the body, giving the double pull-off as described for the Austrian Mannlichers.

Action of the bolt mechanism.

On turning up the bolt lever the cocking piece is prevented from rotating by the stud (27) engaging in the groove in the tang, but it is forced back by the action of the cam face of the recess (10) working against the tooth (28), which then enters

the groove (11). This draws back the striker and partly compresses the mainspring. The sear bent is depressed by the cocking piece stud as the latter passes back over it. While the bolt lever is being turned up, the lugs on the bolt travel along the cam-shaped grooves, leading from their seating (3, 3), and thus draw back the bolt and effect the primary extraction. The lugs on the bolt are now in the grooves (1, 1), and the bolt lever (8) being opposite the opening between the sides of the body the bolt can be withdrawn. In the Dutch pattern the ejector strikes against the tooth of the retaining bolt and moves forward till stopped by the left lug on the bolt; this ejects the cartridge as before described and stops the backward motion of the bolt. In the Roumanian pattern the tooth of the ejector enters the slot (21) in the bolt-head and ejects the cartridge just before the bolt is stopped by the left lug striking the tooth of the retaining bolt.

On pushing the bolt forward the bolt-head strikes the base of the top cartridge in the magazine and pushes the bullet up the slope at the front of the magazine into the chamber; the base of the cartridge slides up the face of the bolt-head as the cartridge aligns itself with the axis of the bore, and the hook of the extractor engages the rim of the cartridge. When the lugs on the bolt arrive at the end of the grooves (1, 1) the the cocking piece stud engages the sear bent, so that when the cartridge is forced home and the bolt locked, by turning down the bolt lever, the mainspring is finally compressed. If necessary the rifle may be full cocked by turning the bolt lever up and lowering it again. If the bolt lever is not fully closed when the trigger is pulled, the tooth (28) on the cocking piece strikes against the cam face of the recess (10) on the bolt, and closes it. To strip the bolt, press the safety bolt forward until its rear end is clear of the recess (48) in the striker nut, unscrew the latter, and the safety bolt and cocking piece can be removed. Then turn the bolt-head until the stud (15) is opposite its clearance and draw it out of the bolt; the striker and mainspring can then be removed.

The front part of the trigger guard forms the magazine. Magazine.
The clip containing 5 cartridges with rims is inserted bodily into the magazine. At the rear end of the magazine a catch is pivoted on a screw (49) and is actuated by a spiral spring (50). The tooth (51) engages a projection on the back of the clip and holds it in the magazine until all the cartridges are used, when the clip falls out of the opening (52). The back of the magazine and the ribs (52*a*) on each side of the magazine act as guides for the clip. The forward part of the bottom of the magazine is closed by a trough-shaped piece (53), secured in front by a screw (54). The elevator (55) is pivoted on a pin (56) in the front end of this trough, and is actuated by the flat spring (57), the rear end of which fits under projections (58) in the trough. In the Roumanian rifle there is a small platform (59) pivoted on the end of the elevator, and actuated by the

spiral spring (60). In the Dutch pattern the end of the elevator is rounded off, the platform being omitted. A full or partially emptied clip may be removed by pressing forward the boss (61) of the catch, thus drawing back the tooth and allowing the elevator to throw the cartridges and clip up out of the magazine. At either end of the trigger guard are countersunk holes for the heads of the screws which fix it to the body.

Stock and furniture. The stock is in a single piece without pistol grip, but with thumb and finger grooves for the left hand. The upper band is secured by a screw passing through it and the fore-end. In the Roumanian pattern the sword bar for the bayonet is on the right of the upper band, and a short rod ending in a knob screws into a projection on the left, as in the Austrian rifle. In the Dutch pattern the upper band is partly enclosed in front to form a nose-cap; the sword bar is below the barrel and is bored out for the cleaning rod. In both rifles the lower band is secured by a spring let into the right side of the stock, a sling swivel being pivoted to a projection underneath the band. The other sling swivel is pivoted to a projection on a small plate screwed on to the underside of the stock. The butt plate is attached by two screws; in the Roumanian pattern it is thin and broad particularly at the toe. The wooden handguard extends from the body to the lower band, it is 5 inches longer in the Dutch pattern on account of the lower band being further forward. In both patterns the handguards are held on by spring clips that grip the barrel, as in the Lee-Enfield rifle. The magazine stock and body are joined together by two screws which pass through the ends of the trigger guard into bosses near the ends of the body.

Cleaning rod. The half length cleaning rods are screwed and tapped at the ends so that two may be joined together. In the Dutch pattern one end is provided with a rag slot. The ends of the rods screw into a nut let into the stock at the end of the rod groove.

Sword bayonet. In the Dutch pattern the sword bayonet is fixed below the barrel. The blade is double edged and is diamond shaped in cross section. The wooden grips are attached by means of rivets and washers. The steel scabbard is provided with a loop near the mouth-piece for attaching it to the equipment. All the steel work of the bayonet and scabbard is browned. In the Roumanian pattern the bayonet, which fixes on the right side of the barrel, has a broad back, but is double edged near the point. Near the back of the blade is a broad flat-bottomed groove or fuller. The wooden grips are attached by rivets and washers. The steel work of the bayonet is left bright. The steel scabbard is browned and is provided with a hook for attaching it to the equipment.

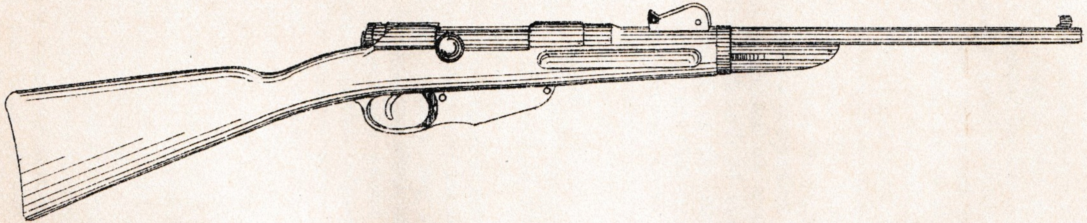
Clip. The clips for both rifles are very similar (see Plates LXIV and LXV). They are made of tinned sheet steel and hold 5 rim cartridges. At the back in the centre is a projection by means of which the clip is held in the magazine by the tooth (51) of the catch. The clips can be inserted either end up.

For weights and dimensions, see Table IV, Appendix.

Plate XXXVIII.

HOLLAND MANNLICHER CARBINE 1897.

To face page 77.



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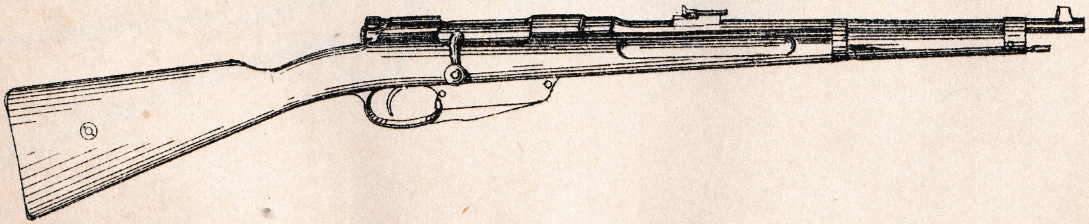
ROUMANIA MANNLICHER CARBINE 1893.

Plate XXXIX.

To face page 77.



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CARBINES.

Holland: Mannlicher, 6·5 *mm.*, ·256-*inch*, *Pattern* 1897.
Roumania: „ „ „ „ 1893.

The Dutch carbine is very similar to the rifle used by the same power, but is shorter.

The backsight has a bar on each side of the leaf, similar to the bar (*d*) on the right side of the leaf in the rifle. It is graduated from 400 to 2,000 metres, even hundreds on the right. The fore-end extends about half-way between the body and the muzzle. There is no nose-cap. The band, which is just in front of the backsight, carries a Dee for the sling on its left side. The other sling swivel is attached to a plate which is screwed to the left side of the butt. The left side of the magazine, and part of the opening in the trigger guard for the forefinger, are covered by a piece of wood extending downwards from the stock to protect them. No cleaning rod is carried on this carbine.

The Roumanian carbine is similar to the rifle, pattern 1893, but is shorter.

The backsight leaf is graduated from 600 to 1,800 metres. At the rear end, at right angles to the leaf, is a projection in which the fixed sight notch for 500 metres is cut. The slide is a plain one which depends upon friction to keep it at any required elevation. The upper band is not provided with a bar for the sword bayonet. The lower band has a Dee on the left side for the sling. The other end of the sling is attached to the butt swivel, the stem of which passes through the butt and is screwed into a nut on the right side. The bolt lever is turned down for convenience in carrying the carbine in a bucket.

GREECE.

Mannlicher-Schoenauer, 6·5 *mm.*, ·256-*inch*, *Pattern* 1903,
Manufactured 1906, *Steyr.*

This rifle differs from the Roumanian Mannlicher rifle described above, in the following particulars:—

The outside of the barrel is a straight taper from the muzzle to 3·15 inches from the front of the body, where the diameter increases from ·7 inch to ·785 inch, forming a shoulder against which the sleeved backsight bed is butted and fixed by soldering, a pin passing through the rear top end of the bed and the barrel. Barrel.

A block band foresight is sleeved on the muzzle end of the barrel, a large adjustable barleycorn foresight being dovetailed into the block at right angles to the axis of the barrel. Foresight.

Backsight. The sleeved backsight bed is cut away in the centre on the underside, forming bands at the front and rear ends. Ramps are formed on the sides and the centre of the bed, at the top, is cut away for the leaf which is pivoted by a screw at the front. The sight spring is tucked into a recess at the rear of the leaf slot, and held in position by the leaf. The outside of the left ramp is marked in even hundreds from 400 to 2,000.

The sight leaf (similar to that of the rifle, short M.L.E., Mark I, but without windgauge or fine adjustment) has a rack cut on the right side for positioning the slide, and is marked in even hundreds from 200 to 2,000 on the top. The sight slide is fitted with a catch, operated by a spring which is compressed by pressure of the thumb on the head of the catch, on the left side of the slide which liberates the catch from the rack of the leaf.

Body. At the rear end of the opening at the top of the body charger guides are formed, the front of these guide-grooves being sloped up to effect ejection of the empty charger when the bolt is closed. The underside of the body is continued downwards and shaped to form the top part of the magazine.

Magazine. A rectangular box forming the bottom part of the magazine is fitted into the bottom of the body, and held in position by a bottom fixing plate, pivoted in the centre at the bottom of the box; each end of this plate, when revolved, enters radial locking grooves, cut in the front and rear of the downward extensions of the bottom of the body, which forms the top part of the magazine. The magazine bottom fixing plate is retained in position by a spring which enters a recess in the plate.

In the rectangular box, forming the bottom part of the magazine, a rotary platform is fitted. The platform is bored to receive front and rear axis studs attached to a spiral spring. The axis studs are grooved to receive, and prevented from turning by, two retaining pins, fitted in the axis hole of the platform. The platform is provided externally with 5 grooves to receive the cartridges.

As the cartridges are charged the magazine platform is rotated and the spiral spring coiled, its tension being thereby increased (a certain amount of tension is on the spring when assembled with studs to the platform). By the expansion of the spring the platform is rotated, and the cartridges forced up to a cartridge stop projecting into the boltway. The thumb-piece of the cartridge stop projects through a slot cut in the top on the right side of the body where it is pivoted. When charging the magazine the cartridge stop is depressed by the cartridges. If it is desired to remove the cartridges from the magazine the cartridge stop is depressed by pressure on the thumb-piece, when the cartridges are ejected out of the magazine.

Bolt. The bolt is arranged for a safety catch of the Roumanian pattern, and an ejector of the Dutch pattern. It has, also, a projecting cocking piece stop stud in front of the cocking cam, which prevents the cocking piece being overturned to the right

when in the cocked position for insertion in the rifle. The knob of the handle is larger, and is bored out for lightness, the rib of bolt being also milled out for the same reason.

The striker is attached to the cocking piece and striker nut by interrupted rings. Striker.

The underside of the top rib of the cocking piece is grooved on the right side to clear the stop stud on the bolt, and the striker hole is bored with interrupted rings for attachment to the striker. Cocking piece.

The striker nut is bored with interrupted rings for attachment to the striker. Striker nut.

The stock is formed with a pistol grip, and has two long lightening grooves cut at the bottom of the barrel groove. Stock.

The sword bar for the sword bayonet is underneath the barrel. Upper band.

The guard consists of a bow with tang; the front part has a hook which hooks into a hookway cut in the rear bottom extension of the body, and the tang is bored for a screw which passes through the guard and screws into the tang at the rear end of the body. Guard.

To strip the rifle, press the retaining bolt and remove the breech bolt from body. Place the cocking piece in the fired position, push the safety catch forward and turn to the right, turn the striker nut one-quarter revolution to the left and remove from striker, turn the safety catch one-quarter revolution to the left and remove the safety catch, spring and draw the cocking piece off the striker, turn the bolt-head half a revolution to the right, remove bolt-head with ejector and extractor from bolt, and withdraw striker and main spring. Raise the extractor at the front and draw it forward, remove ejector screw and ejector. To strip the rifle.

To remove the rectangular box forming the magazine bottom, and the rotary platform. With the point of the bullet of a cartridge depress the catch, give the bottom fixing-plate one-quarter turn, and lift out; lift platform at front end and remove, slightly depress front axis stud and turn about one-eighth revolution to the right; remove spring and axis studs.

Remove upper band screw and upper band.

Depress lower band spring and remove lower band.

Remove guard screw and guard.

Remove body screw and stock.

The sword-bayonet is similar to that shown in Plate XXXV, and described on page 76, except that the edge is reversed and the bayonet fits on the sword bar on the upper band below the barrel. Sword-bayonets and scabbards.

The scabbard is the same as the Roumanian scabbard described on page 76.

ITALY.

Mannlicher Carcano, 6·5 *mm.*, ·256-*inch*, *Pattern* 1891.

This rifle has the Mannlicher clip system of loading, similar to that employed in the Dutch and Roumanian rifles, and the breech mechanism introduced by M. Carcano of the Turin Small Arms Factory.

Barrel. The barrel tapers from the reinforce over the chamber to the muzzle, and throughout its length is rather light. Its chief peculiarity consists in the progressive twist of the rifling, which commences at the breech with one turn in 22·9 inches and ends with one turn in 7·5 inches at the muzzle. A small lump is left on the barrel, just in front of the reinforce, for screwing the rear end of the backsight bed to.

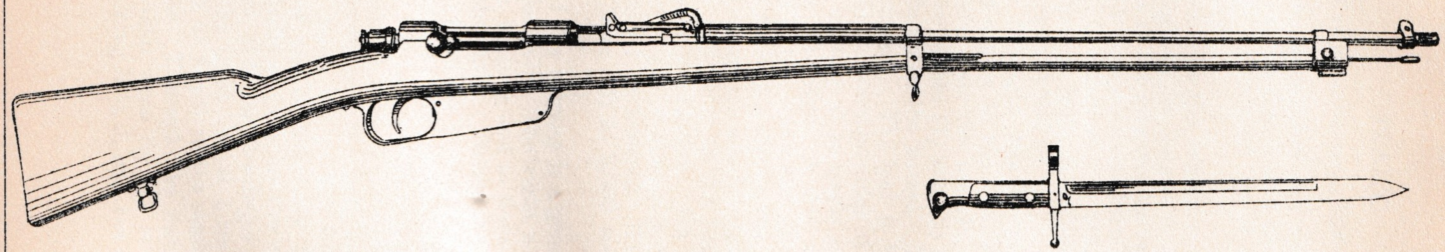
Sights. The barleycorn foresight has its point rounded off; it is dovetailed at right angles to the axis of the barrel into a ring soldered to the barrel near the muzzle. The backsight bed is screwed by the two screws (1) and (2) to a lump on top of the ring (3) and to a lump on the barrel. The ring (3) is screwed to the barrel underneath. The leaf is hinged on the screw (4) and works between the vertical sides of the bed (5). The end of the leaf (6) is bent up at an angle of 45° and has the V for aiming cut in its top edge. A flat spring (7) has one end screwed to the leaf at (8), while the other end passes outside the backsight bed and fits into a slot in the pin (4). On the inside of the spring is a sharp rib which engages in the grooves on the flange on the right side of the bed. These grooves tally with each 100-metre graduation. On pressing the left end of the pin (4) the spring (7) is disengaged from the grooves and the leaf can be raised or lowered. The sides of the bed are graduated on top from 600 to 2,000 metres, even numbers on the right.

Body. On either side of the boltway is a groove (9) for the lugs at the front end of the bolt. The right side is cut away as usual for convenience in loading, and to permit of the cartridge cases being ejected to the right. Below the boltway is an opening, the edges of which form the top part of the magazine. Behind the barrel seating, in the front part of the body, are the seatings (10, and 10*a*) for the lugs on the bolt. These communicate by cam-shaped grooves with the longitudinal grooves (9, 9). In rear of the magazine way the body does not form a complete circle, an opening being left on top for the bolt lever to pass through. The rear end of the body forms a tang which is grooved longitudinally at (11) for the cocking piece stud (25), and transversely at (12) for the finger piece (30) of the bolt plug, E. Under the front end is a transverse rib (13) which transfers the shock of recoil to the stock and which fits into a recess in the latter. Through the underside of the body and tang are four vertical slots for the sear bent (34), the sear axis (33), the retaining bolt, J, and the ejector, I.

Plate XL.

ITALY MANLICHER CARCANO 1891.

To face page 81.



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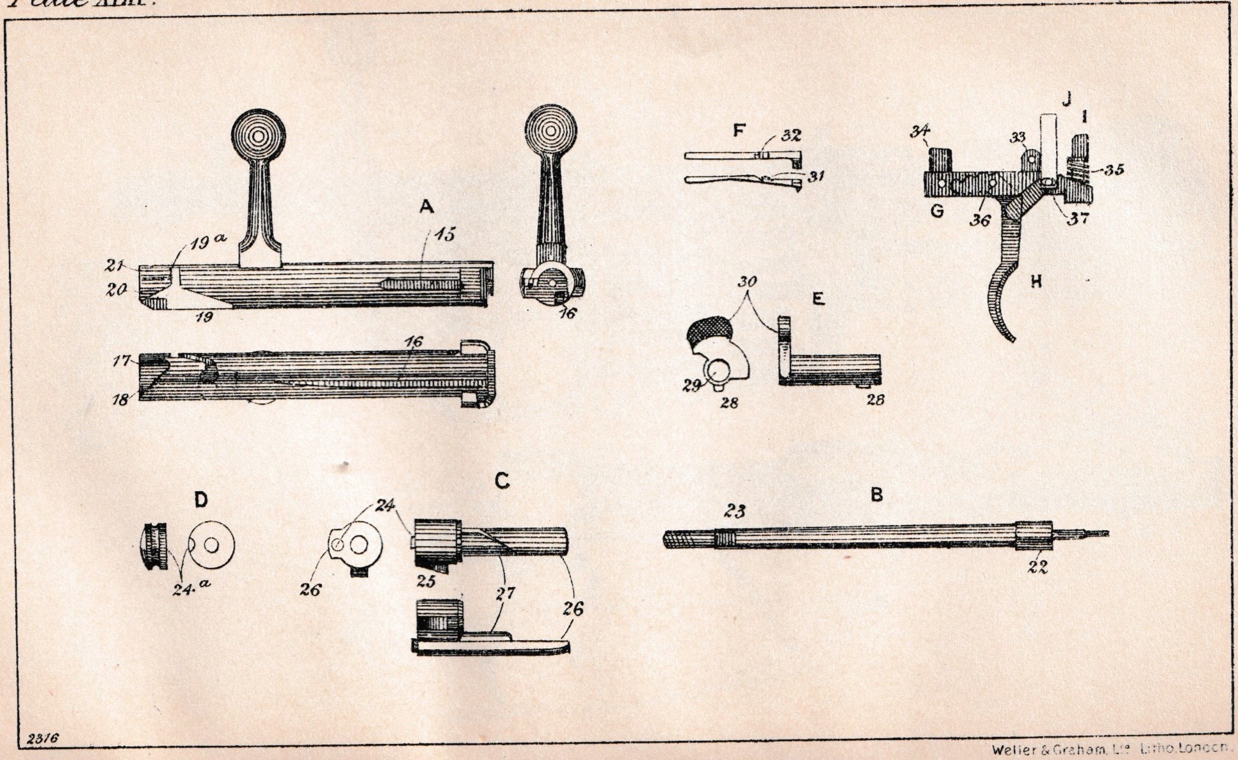
ITALY. 1891. MANNLICHER CARCANO.

Plate XLII.

To face page 81.



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The bolt, A, which has no separate bolt-head, is provided with a lug on each side of its front end. The extractor, F, passes through a slot in the right lug into its seating (15) in rear. The front end of the bolt is recessed to fit the base of the cartridge; the rim of the recess is cut away at the bottom, to allow the base of the cartridge to rise up the face of the bolt, so that the extractor may at once enter into the groove round the base of the cartridge, thus avoiding any chance of double loading (see page 114). Underneath the bolt is a groove (16), gradually increasing in depth towards the front, for the tooth of the ejector, I. The bolt lever, which terminates in a knob, projects at right angles to the bolt, about one-third of the length of the bolt from the rear; it turns down into the opening cut away on the right side of the body. At the rear end of the bolt is a cam-shaped recess (17) for the tooth (27) on the cocking piece; on the rear face is a small groove (18) for the tooth (27) to rest in when the lever is raised. A slot (19, 19*a*), somewhat in the form of an S, is cut in the rear part of the bolt for the stud (28) of the bolt plug. A gas-escape hole leads from the striker way to the top of the bolt near the front end. Bolt.

The bolt can be stripped without the aid of tools, with the exception of the extractor, which requires a screwdriver or punch to dislodge it.

The mainspring consists of 31 coils of ·054-inch wire, set to a length of $5\frac{1}{2}$ inches. Mainspring.

The striker, B, has a collar (22) for the mainspring to bear against, and is threaded at the rear end so that the striker nut, D, may be screwed on. Striker.

The cocking piece, C, fits on to the end of the plain part of the striker, and is prevented from turning on it by a projection, in the striker channel, bearing on the flat (23) on the striker. It is secured by the striker nut, D. This nut cannot be unscrewed until the stud (24), which is actuated by a spiral spring, is pressed flush with the face of the cocking piece. Underneath the cocking piece is the cocking piece stud (25) which works in the groove (11) in the tang of the body. On the left side of the cocking piece is a guiding rib (26) which works in the left groove (9) in the body, and helps to prevent the cocking piece from turning when the bolt is rotated. On the inner side of this rib is a tooth (27) which engages in the recess (17) in the bolt when the rifle is fired. Cocking piece. Striker nut.

The bolt plug, E, fits into the rear end of the bolt, and a groove (21) inside the rear end of the latter admits of the stud (28) entering into the slot (19*a*). The mainspring bears against the front end of the bolt plug, and the striker passes through the hole (29) in the centre of it. The bolt plug acts as a safety arrangement in the following manner:—When the bolt plug is in its normal position the stud (28) is resting in the recess in the extreme end of the slot (19), and when the cocking piece and striker are held Bolt plug. Safety arrangement.

back by the sear bent (34) the mainspring tends to drive them forward. If now the bolt plug is pressed forward and turned round, by means of the finger piece (30), so that the stud (28) rests in the recess (20), the back of the bolt plug bears against the front of the cocking piece, and the latter has no tendency to fly forward; therefore, if the trigger were pulled, cocking piece and striker would remain at rest. If the stud (28) is turned into the end of the slot (19*a*) and drawn out through the groove (21), the striker mainspring, bolt plug, cocking piece, and striker nut are detached from the bolt.

Extractor. The extractor F is inserted into its groove (15) from the front of the bolt, the shoulder (31) springs up behind the lug on the bolt and takes the pull during extraction. The small groove (32) affords a bearing for the end of a screwdriver, or punch, to be used in depressing the shoulder (31) when taking out the extractor. At the front end is the usual claw for engaging the groove round the base of the cartridge. In this rifle the extractor rotates with the bolt, and, consequently, travels partly round the head of the cartridge when the bolt lever is raised (see page 113).

Sear. The sear G has a projection (33) through which passes the axis pin, which pivots it to the body; at the rear end is the sear bent (34) which is fixed to the sear by means of a pin. At the front end is a vertical hole for the spiral sear spring (35) and for the tail of the ejector I.

Trigger. The trigger H works in a slot in the sear and is pivoted on the pin (36). On its top end are three ribs which give the double pull-off described on page 36 for the Austrian rifle. On the right side of the trigger is an arm on the end of which is a projecting pin (37).

Retaining bolt. The retaining bolt has an elongated slot at its lower end into which fits the pin (37). Its upper end passes through a slot in the body into the right-hand groove (9) for the bolt lug, and bars its passage. To withdraw the bolt, the trigger must be pressed; this lowers the retaining bolt, so that the bolt lug can pass.

Ejector. The ejector I rests in its bearing in the front of the sear, and is pressed upwards by the sear spring. Its top end passes through a slot in the body, enters the groove (16) in the bolt, when the latter is withdrawn, and strikes against the left-hand lower part of the base of the cartridge, ejecting it to the right.

Action of the bolt mechanism. On raising the bolt lever the cam face of the slot (17), in the bolt, presses against the sloping face of the tooth (27), on the cocking piece, and forces it to the rear, as it cannot revolve. The cocking piece carries with it the striker nut and striker, partly compressing the mainspring. The end of the tooth then rests in the recess (18) on the end of the bolt. As the bolt lever nears the vertical position, the left bolt lug works against the face of the cam at the front end of the left groove (9) in the body. This forces the bolt back and effects the primary extraction. If the bolt lever were now turned down, the cocking stud would be held

back by the sear bent, and the mainspring would be fully compressed. When the bolt is drawn back after primary extraction, the cartridge case is drawn out of the chamber by the extractor until the base of the cartridge meets the ejector I, which has entered the groove (16) in the bolt; the right side of the cartridge, however, is still drawn back by the extractor, consequently the cartridge is swung out of the rifle to the right. The right lug on the bolt then strikes against the retaining bolt J, and the backward motion of the bolt is stopped. On pushing forward the bolt, its front end strikes the back edge of the top cartridge in the magazine, and pushes it forward into the chamber. As soon as the base of the cartridge is free of the clip it rises, and the extractor engages in its groove. When the cocking stud (25) meets the sear bent (34) the ejector has passed out of the rear end of its groove, and the lugs on the bolt have reached the end of their grooves (9) in the body. On turning down the bolt lever, the bolt is forced forward by the cam-shaped entrance to the bolt lug seatings, the bolt lugs turn in front of their resisting shoulders, and the mainspring is fully compressed. On pressing the trigger the sear bent and the retaining bolt are depressed, the sear spring is compressed, and the cocking piece and the striker fly forward and fire the cartridge.

Magazine. The magazine, which holds six rimless cartridges, is similar to that of the Dutch Mannlicher (see page 75).

Clip. The clip (see Plate LXV) holds six cartridges, and is similar to that of the Dutch and Roumanian rifles described on page 76, but as the cartridges have no projecting rims, they lie nearly parallel to each other, and consequently the back of the clip is straight instead of being curved.

Stock. The stock is in a single piece without pistol grip. It is lightened by having a deep recess, 9 inches long, cut at the bottom of the barrel groove commencing under the backsight. The projection (13) on the barrel fits into a steel-lined recess in the stock. The body, stock, and trigger guard, with magazine, are held together by two screws passing through the ends of the trigger guard into the projections (13, and 14) on the body.

Bands, cleaning rod, &c. The upper band is fixed to the stock by a transverse screw. Underneath it is the usual bar for fixing the bayonet, and at its front end is a small loop, through which the full length cleaning rod passes, and into which a projecting thread on the rod screws. At one end of the rod is a slot for the cleaning rag, at the other end is a thread, probably for use with some clearing tool. The lower band is not divided at the bottom, and is held in position by a spring let into the stock. A projection on the underside carries a sling swivel. The other sling swivel is pivoted to a plate attached to the underside of the butt by two screws. A short handguard extends from the backsight to the lower band; the rear end tucks under the front end of the backsight bed, and a steel tongue riveted to the front end fits in a groove in the lower band. The steel butt plate is attached by two screws in the usual way.

Sword bayonet.

The blade of the sword bayonet is straight, and has a broad back, but is double edged for about 2 inches from the point. A broad flat-bottomed fuller runs close to the back to within 3 inches of the point. The cross bar, handle, and locking bolt are similar to those on the English bayonet, Pattern 1888. The bayonet when fixed is underneath the barrel. All metal parts are left bright. The scabbard is of black leather, with brass locket and chape; a brass stud is soldered and screwed to the former for attachment to the frog.

For weights and dimensions, see Table IV, Appendix.

Carbine.

Italy Mannlicher Carcano 6·5 *m.m.* ·256-*inch, Pattern* 1891.

This carbine is similar to the rifle Pattern 1891, but is shorter, and has a bayonet permanently fixed to it. The other points of difference are as follows:—

Bolt.

The bolt has the lever turned down to facilitate stowage in the cavalryman's bucket.

Sights.

The barleycorn foresight is dovetailed into its block at right angles to the axis of the barrel, its rear face being sloped at the same angle as its front face. The backsight is on the same principle as in the rifle, but the leaf is so short that the right side of it is extended to the rear to allow of a spring catch of sufficient length being used on the right side. When aiming at medium elevations, this gives the sight a one-sided appearance. The bed is graduated from 600 to 1,500 metres, even hundreds on the right. In its lowest position the sight gives the elevation for 500 metres.

The stock is in one piece, and the butt being 1½ inches shorter than that of the rifle, makes the carbine awkward to handle. The fore-end extends half-way up the barrel. At the end is the single band attached by means of a transverse screw. On the left side of the band is a bar for the front end of the sling, and on the left side of the butt is a recess, across which extends a bar, fixed by means of a screw at each end, for the rear end of the sling.

Bayonet.

The bayonet, which is carried attached to the carbine, is pivoted to the screw (1), which passes through two plates (2), which project downwards from the socket (3), which fits over the end of the barrel. The rear end of the socket (4) stands up on either side of the foresight block, and is attached to it by a screw (5). The blade of the bayonet is triangular, and the pivoted end rectangular, the latter being held in the "fixed" and "secured" positions by means of the catch (6), the end of which enters the bearings (7) and (8). The catch is pressed towards the pivot (1) by means of a spiral spring within the thick part of the bayonet. When the bayonet is secured to the rear, the end of the blade lies in a groove in the fore-end and nose-cap band. All parts of the blade and socket are browned.

Plate XLIII.

ITALY. MANNLICHER-CARCANO CARBINE 1891.

To face page 84.

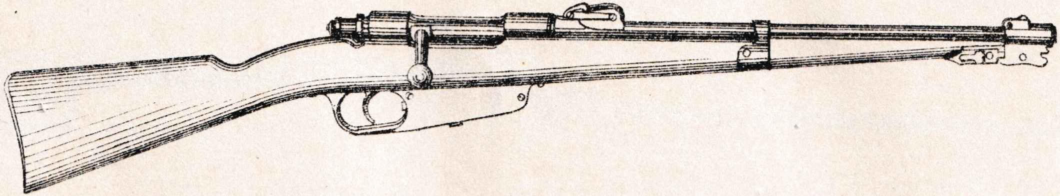

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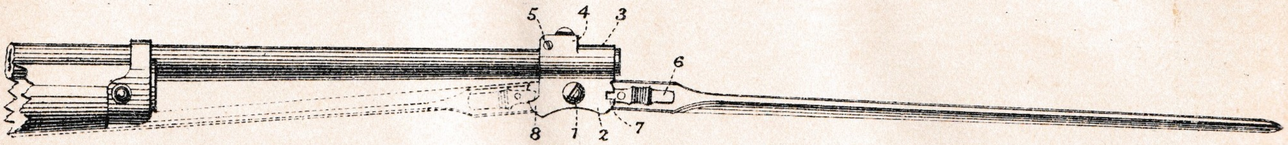
Plate XLIV. ITALIAN CARBINE. MANNLICHER CARCANO.

To face page 84



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JAPAN. YEAR 38TH PATTERN. 1907.

Plate XLV.

To face page 85.

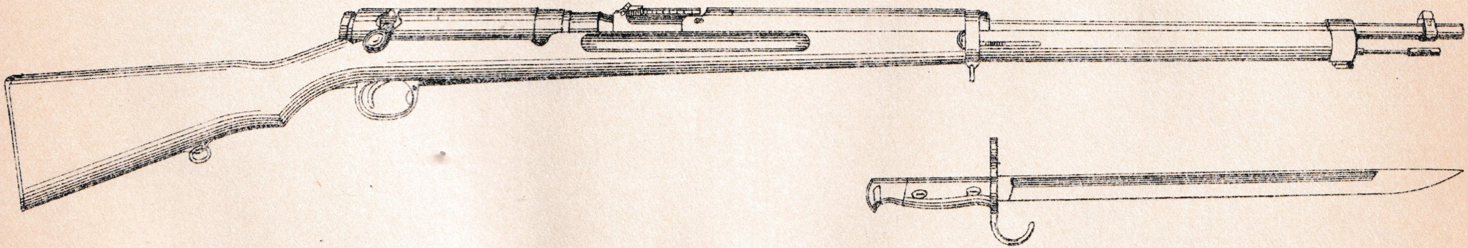

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Plate XLVI.

JAPAN. YEAR 38TH PATTERN. 1907.

To face page 85.

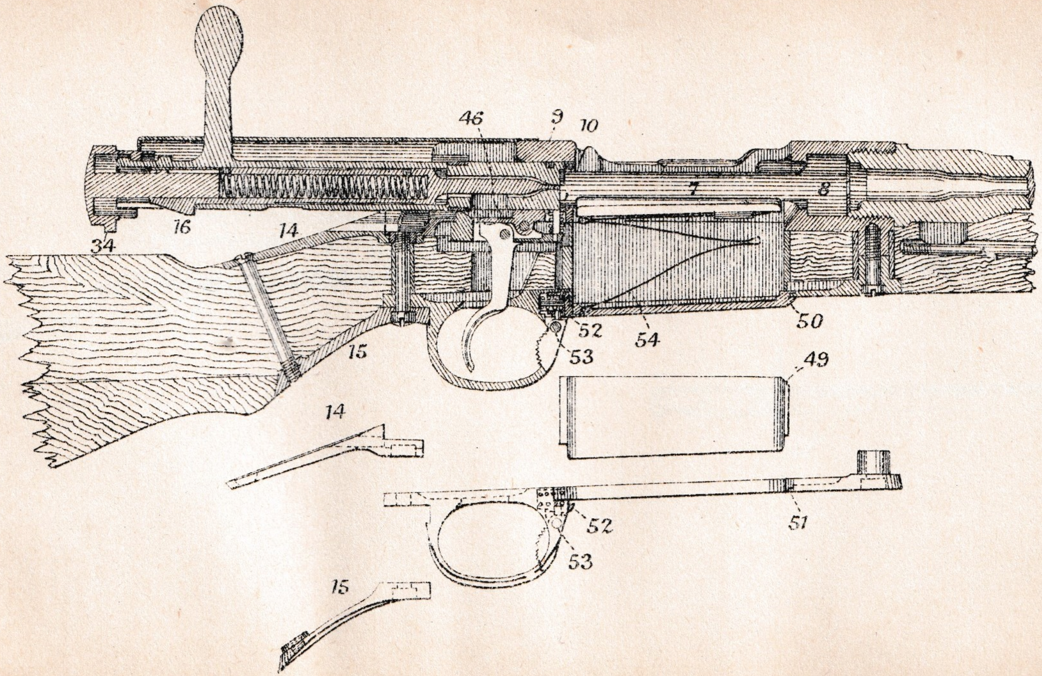
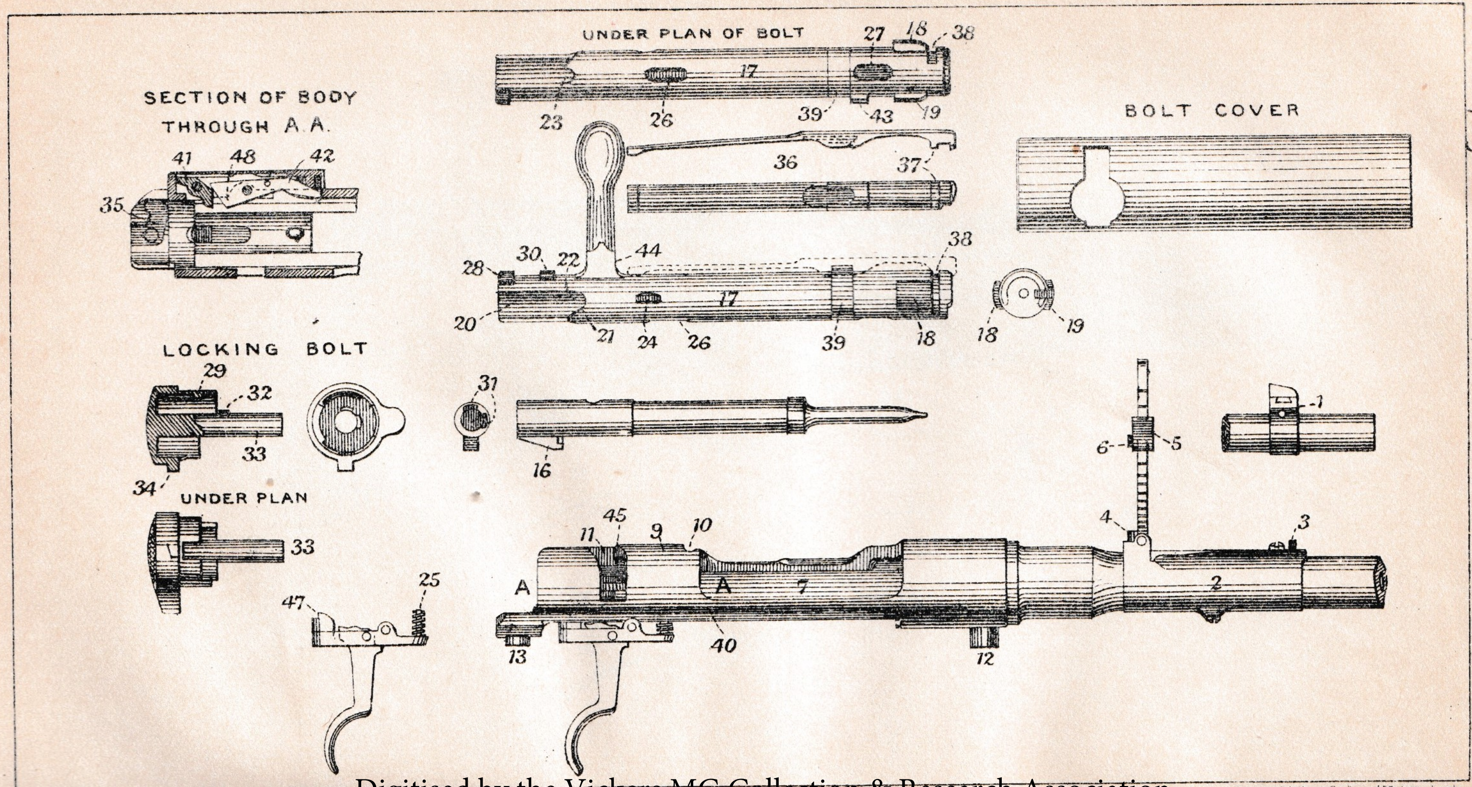


Plate XLVII.

JAPAN. YEAR 38TH PATTERN. 1907.

To face page 85.



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The carbine is light (6 lbs. 14¾ oz.), and can be held with one hand at the small, and used as a thrusting weapon; the distance from small of the butt to point of bayonet is 40 inches, and would give a greater reach than could be obtained with any sword now in use.

JAPAN.

Year 38th pattern. Introduced 1907. *Bore* ·256 *or* 6·5 *m.m.*

The design of this rifle is largely borrowed from the Mauser.

The barrel, which is polished and browned, tapers from the reinforce over the chamber to the foresight, whence there is a small step to the muzzle. There is no "Knox form." **Barrel.**

The foresight block (1) forms part of a ring which butts up against the shoulder of the step on the barrel, it is held in position by a cross screw. The barleycorn foresight is dovetailed into the block at right angles to the axis of the barrel. The backsight bed (2) forms part of a sleeve which butts up against the reinforce, and is held in position by a screw underneath. The leaf is pivoted at its rear end, and is controlled by a flat spring in the usual way. The latter is dovetailed and screwed to the bed, and is provided with a stud (3) of the same breadth as the opening in the leaf. When the latter is down, this stud supports the leaf against lateral blows. At right angles to the rear end of the leaf is a short leaf (4) with a notch for 400 metres elevation. The face of the leaf is graduated from 500 to 2,000 metres. On the right side of the slide a small catch (5) is pivoted on the screw (6). At the bottom of the catch next the leaf is a small tooth, which engages in slots cut on the edge of the leaf, one to each 100 metre graduation. The tooth is kept pressed against the leaf by a small spiral spring inside the upper end of the catch. The slide cannot be lowered, but may be raised, without pressing the catch; it cannot, therefore, slip down when firing. **Sights.**

The body which screws on to the breech end of the barrel, has a groove (7) cut on either side of the boltway for the ejector and the lugs on the bolt to travel in. The grooves (7) lead to the seatings (8) for the lugs on the bolt. The right side of the body is cut away for convenience in loading and ejection. In rear of the cartridge opening, in the body, the bolt passes through a cylindrical portion (9), on the front part of which is a guide recess (10) for the charger. In rear of the cylindrical portion is a recess (11) for the bolt lever. The underneath part of the body forms the top of the magazine, and is provided with the usual opening for the cartridges to ascend through. On the underside of the body near the front and rear ends are two threaded bosses (12) (13) for the screws, which hold the trigger guard, stock, and action together. **The body.**

The front boss (12) fits in a steel collar in a recess in the stock. There are two tangs (14, 15), separate pieces, which

form extensions of the body and trigger guard respectively, and tend to greatly strengthen the butt stock at the pistol grip; the upper tang has a groove cut in it for the cocking toe (16). The rear boss (13) fits in a square hole in the front of the upper tang (14), which is also fixed to the lower tang by a screw. These bosses communicate the recoil of the barrel and body to the stock.

Bolt. The bolt (17) is of the Mauser type. It can be stripped and assembled without the use of tools. Its front end is provided with two lugs (18, 19), and is countersunk to take the base of the cartridge. The bolt is bored out from the rear end for the cylindrical striker. The walls of the bolt are cut away in rear (20) to form an opening through which the cocking toe (16) projects. The front of this opening forms a cam (21), joining the two recesses (22, 23) for the cocking toe. The groove (24) is for the front safety stud (25) of the sear to enter. This arrangement ensures that the rifle can only be fired when the bolt is fully closed. A second groove (26) allows clearance for this stud when the cocking toe passes over the sear in loading. A large gas-escape hole (27) is drilled 1 inch from the front of the bolt to permit of the escape of gas from a defective cartridge. There is a circumferential rib (28) on the rear end, which engages with a similar rib (29) inside the locking bolt, and there is also a small lug (30), by means of which the bolt is locked in the ready position.

The mainspring is formed of steel wire, with 41 coils, set to a length of 4·2 inches.

Striker. The striker and cocking piece are made in one piece. It is bored from the rear end to a depth of 4·2 inches to take the mainspring, and has a cocking toe (16) formed on its rear end. In the interior at the rear end are cut two longitudinal guide grooves (31), in which a stud on the locking bolt (32) moves.

Locking bolt. The locking bolt is in the form of a cylindrical cap on the rear end of the bolt, with a stem (33), which fits into the striker and bears against the mainspring. It can be placed in the safety position only when the action is cocked. To lock the action, the locking bolt is pressed forward and then turned to the right, the movement to the right being limited by the travel of a stud (34) on the undersurface of the locking bolt in a groove (35) in the body; thus the mainspring is compressed; a stud (32) on the stem of the locking bolt engaging in the guide groove (31) in the striker turns the striker with the cocking toe clear of the sear; the ledge on the forward edge of the locking bolt engages with the stud (30) on the bolt, which is thereby locked; the locking bolt itself is held by the weight of the mainspring, with the stud (34) on the rim forced back into a recess (35) in the groove in the rear of the body. When the locking bolt is disengaged, the weight of the mainspring is transferred from the point of the stem of the locking bolt (33) to the circumferential rib on the bolt (28), which engages with the rib (29) inside the cylinder of the locking bolt.

Extractor. The extractor (36) consists of a long steel spring, extending from the front end of the bolt nearly to the bolt lever. It is provided with the usual claw to grip the cartridge. It has a small rib (37), on its underside, which works in a canneluro (38) round the head of the bolt, and prevents the extractor from being drawn to the front; it is fixed by a dovetail to a split ring (39), which works in another cannelure; thus the bolt is free to turn without moving the extractor.

Bolt cover. The bolt cover is semi-circular in cross-section, and is retained in guide grooves (40), on either side of the body, in which it moves. It encases the whole of the top of the body when the breech is closed. The bolt lever passes through a slot in the cover, and draws the latter backwards or forwards.

A box extension on the Mauser principle is on the left side of the body at the rear end, and encloses the bolt-stop (41), spring, and ejector (42). The ejector is thus entirely separated from the bolt, and is brought into action by a stud (43) on the bolt, when the latter is fully drawn back.

Action of the bolt mechanism. On raising the lever of the bolt to open the action, the cocking toe (16) travels along the inclined plane (21) on the bolt and springs into the recess (23). This draws back the striker. As the bolt lever nears the vertical position, the lower end of it (44) travels along an inclined plane at the back of the cylindrical part of the body (45); this forces the bolt slightly to the rear, and forms the primary extraction. The striker, cannot revolve when the bolt is rotated on account of the cocking toe (16) being engaged in the groove (46) in the body; the extractor çannot revolve as it engages in the right-hand groove (7) in the body. The lugs of the bolt (18, 19) are now clear of their seatings, and opposite the ends of the grooves (7). On drawing the bolt to the rear, the cocking toe (16) passes over the bent of the sear (47), and depresses it; the safety stud (25) is thereby raised and enters the clearance (26) cut for it in the bolt. On drawing the bolt fully back, the rear end of the ejector (48) comes in contact with a lug (43) on the bolt, the front part of the ejector strikes the base of the cartridge on the left, and ejects it to the right, and the bolt is arrested by the lug on the bolt (43) striking against the bolt stop.

In closing the bolt, the bolt-head meets the base of the top cartridge in the magazine; the bullet rises up an incline cut in the body in front of the magazine; and guides the cartridge into the chamber. The base rises up the face of the bolt-head, and the extractor engages in the groove in the base of the cartridge. When the cocking toe (16) meets the sear bent (47), the striker is held back, while the bolt and locking bolt continue their forward motion, compressing the mainspring until the bolt lever meets the cylindrical part of the body (45). On turning down the bolt lever, the lugs on the bolt pass out of the grooves (7) and place themselves in front of their seatings in the front part of the body. On pulling the trigger

the sear bent (47) is depressed, and the cocking toe and striker are released as before described.

Magazine.

The magazine, which holds five cartridges in two columns, is made of sheet steel; the bottom part fits into the opening made for it in the trigger guard, and the projection (49) on the front end, engages in the body. The bottom is closed by a plate, a hook (50) on the front end of which hooks into the trigger guard at (51). The back end of this plate is supported by the tooth (52) of a small catch pivoted on the pin (53) in the bow of the trigger guard; the top end of the catch is kept pressed forward by a small spiral spring. The platform is cut so that the right side is higher than the left, thus bringing the centres of the cartridges in one column opposite the top or bottom edges of the cartridges in the other column. Underneath the rear end of the platform, is a rib which forms a seating for the zigzag magazine spring (54), the front end of which is held by two undercut projections on either side; while the other end is secured in under-cut recesses in the bottom plate. The opening in the body forms the top part of the magazine; its sides overhang slightly so as to form stops for the top cartridge in each column; the cartridges are thus prevented from being pushed out of the magazine by the upward pressure of the magazine spring. When the magazine is empty, the rear edge of the platform prevents the bolt from being closed, and so indicates to the soldier that the magazine requires refilling.

For weights and dimensions, see Table IV, Appendix.

PORTUGAL.

Mauser-Virguiero, ·256-*inch*, *Pattern* 1904.

For weights and dimensions, see Table IV, Appendix.

ROUMANIA.

Mannlicher 6·5 *m.m.*, ·256-*inch*, *Pattern* 1895.

(See page 71.)

RUSSIA.

Line, 7·62 *m.m.*, ·3-*inch*, *Pattern* 1900.

This rifle follows Patterns 1891 and 1894 of the same type of rifle which are known by the designations, 3 Line, Nagant and Mossin.

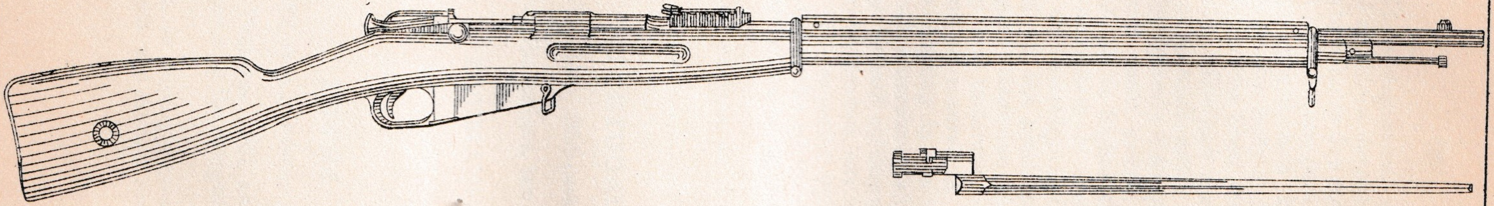
Barrel.

The barrel, which is strongly reinforced over the chamber, tapers slightly towards the muzzle and screws into the body in the usual manner.

Plate XLVIII.

RUSSIA. 3 LINE RIFLE 1900.

To face page 89.



2316.

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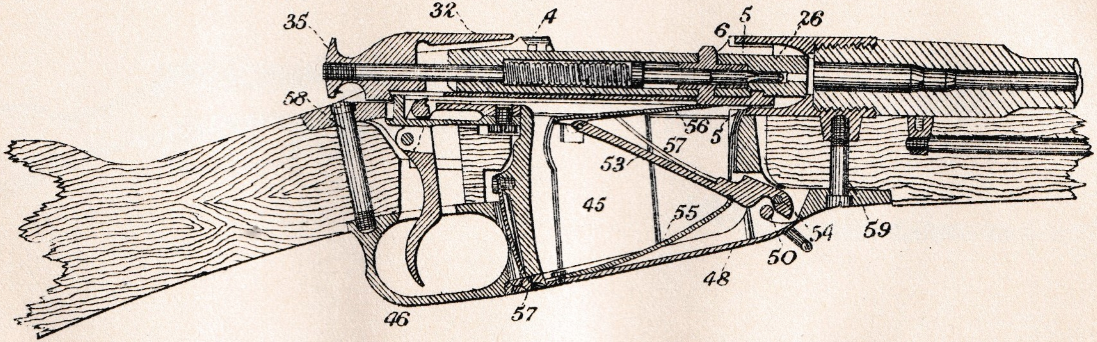
RUSSIA. 3 LINE. PATTERN 1900.

Plate XLIX

To face page 89



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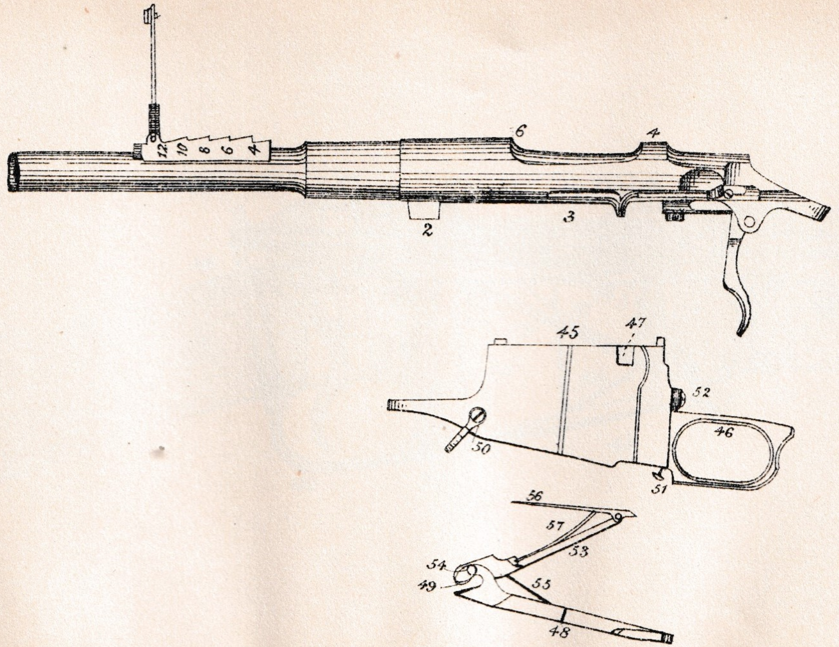
RUSSIA. 3 LINE. PATTERN 1900.

Plate L

To face page 89.



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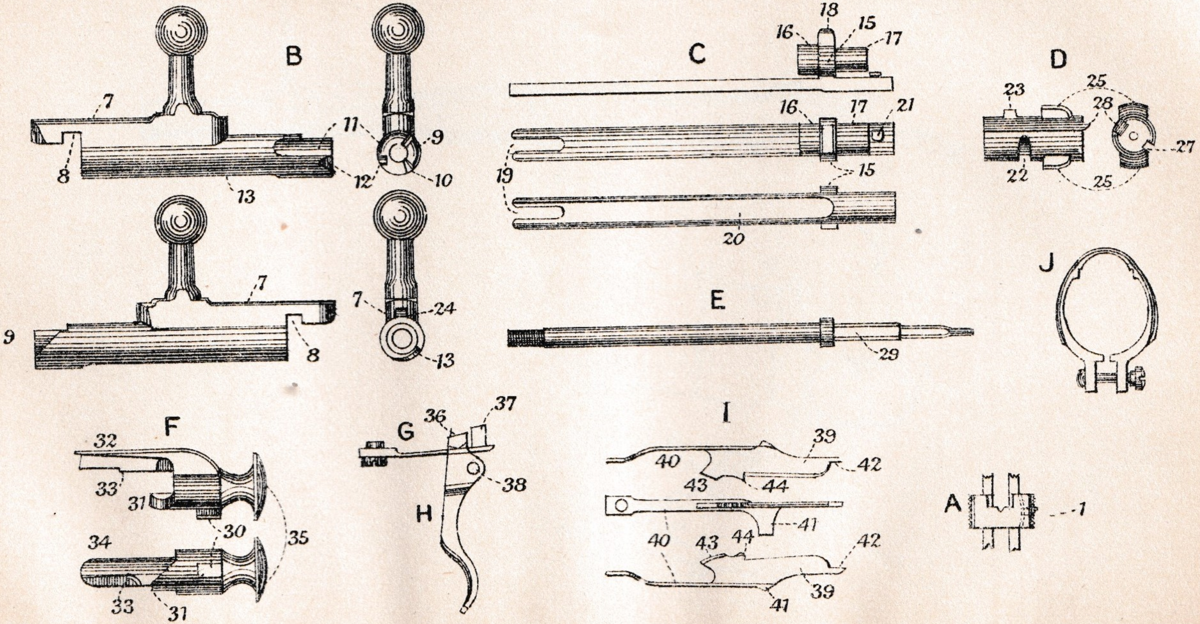
RUSSIA. 3 LINE PATTERN 1900.

Plate LI.

To face page 89.



2316.

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The foresight block and backsight bed are brazed on to the barrel. The barleycorn, which is rather high and narrow, is dovetailed into its block at right angles to the axis of the barrel. The leaf of the backsight is hinged to the front end of the bed. A cap is formed on the end of the leaf and is provided with a very small v, the sides of which make an angle of 60° to each other. The slide A maintains its position wherever it is placed by friction against the edge of the leaf. For this reason a small slightly curved spring (1) is introduced between the slide and side of the leaf. A small stud is formed on the back of this spring, and enters a hole in the side of the slide, while a small screw bearing on the end of this stud enables the friction to be regulated. Sights.

Grooves are cut in either side of the cap to enable the slide to be taken on and off. Ramps are formed on either side of the bed and are provided with steps giving the elevation for even hundreds of paces, from 400 to 1,200. The leaf is graduated from 1,300 to 2,700, odd numbers on the right. The leaf is controlled by the usual flat spring dovetailed and screwed to the bed. See Fig. 8, page 107.

The body has the usual opening for the magazine beneath the boltway and is cut away on the right to facilitate ejection and loading. The rear part of the body is open on top to permit of the passage of the bolt lever and rib; it is grooved behind the magazine opening for the connecting bar C and the cocking piece stud (30), and the extreme end is formed into a tang. Beneath the front end is a square projection (2) which transfers the shock of recoil to the stock. In the left side, above the magazine opening, is a slot (3) for the body of the interrupter I. A slot is also cut in the under part of the body to permit of the bent of the sear (37) and retaining stud (36) entering the groove for the connecting bar. Body.

Above the rear end of the magazine way is a projection (4) in which vertical grooves are cut to support the charger. The lugs (25) on the bolt-head enter the front part of the body by the grooves (5, 5). Cam-shaped grooves communicate with the seatings (26) for the lugs, which are horizontal when the breech is closed, instead of being vertically one above the other as in the Mauser and Mannlicher rifles.

The bolt B is of complicated construction. It is provided with a separate bolt-head D (which, however, turns with the bolt), and with a connecting bar C, which acts as a guide to the cocking piece, and helps to retain the bolt in the body. Bolt.

On top of the bolt extending over its front end is a rib (7) which has a recess (8) on its under side for the projection (18) on the connecting bar. The bolt handle projects at right angles to the rib and terminates in the usual knob. At the rear end of the bolt is a cam-shaped recess (9) for the tooth (31) of the cocking piece. A small recess (10) is also provided for this tooth when the bolt lever is raised. Another cam-shaped recess (11) affords clearance for the safety tooth (33)

on the cocking-piece. Another recess (12) is provided for the safety tooth to lock into; a cam-shaped groove (13) on the under side of the bolt operates the rib of the interrupter. The bolt can be stripped without the use of tools.

Connecting bar.

The connecting bar C consists of a long bar which lies underneath the bolt and fits in a groove cut for it at the bottom of the boltway. On top of this bar is a projection (15) in which a hollow cylinder is fixed. The rear part (16) of this cylinder fits into the front part of the bolt. The front (17) of the cylinder fits into the bolt-head. The top part (18) of the projection fits into the recess (8) in the rib, and keeps the bolt and connecting bar together. The stud (30), on the cocking piece, works in a slot (19) in the rear end of the connecting bar. Underneath is a long groove (20) for the retaining tooth (36) on top of the trigger.

Bolt-head.

The bolt-head D fits on to the projection (17), on the connecting bar, and is retained on it by the tooth (21), on the connecting bar, fitting into the groove (22) in the bolt-head. The stud (23) engages in the recess (24) in the front end of the rib of the bolt, and forces the bolt-head to turn with the bolt. On the bolt-head are two lugs (25) which lock in recesses (26), in the front part of the body, on either side of the boltway. The groove (27) is for the ejector tooth (44). The rear end of this groove is widened to admit of the tooth (21) being introduced along it into the groove (22). The face of the bolt-head is recessed for the cartridge head.

Mainspring.

The mainspring is introduced into the bolt from the front, and bears against a shoulder near the rear end. It is made of 28 coils of ·05 inch wire set to a length of 4 inches.

Striker.

The striker E is attached to the cocking piece by means of a thread on its rear end. A collar is formed on it for the front end of the mainspring to bear against. The part in front of the collar passes through the cylinder (16), (17) on the connecting bar, and on this part there are flats (29), on both sides of the striker. As the hole in the cylinder (16) has similar flats in it, the striker is prevented from turning.

Cocking piece.

The cocking piece F screws on to the rear end of the striker. Underneath its rear end is a stud (30), which works in the slot (19) in the connecting bar, and engages with the bent of the sear (37). The tooth (31) engages in the recess (9) in the bolt when the trigger is pressed. There is a projection (32), which passes over the rear end of the bolt, and works in the slot, through the cylindrical portion of the body. On the underside of this projection there is a tooth (33) which, when the cocking piece is pulled back by hand, and revolved to the left, fits into the recess (12) on the rear end of the bolt. This prevents the rifle from being fired, or the bolt from being opened.

Safety arrangement.

The clearance (34) on the projection is provided to enable it to pass over the left side of the body, when it is placed in the position of safety. On the rear end is a large button (35) with its edge roughened to afford a grip.

The extractor (28) fits into a groove in the bolt-head. The rear end of this groove is undercut, and the rear end of the extractor is bevelled so as to fit it securely. The extractor, the front end of which is free to rise, ends in the usual hook which projects over the face of the bolt-head. **Extractor.**

The backward movement of the bolt is stopped by the retaining tooth (36) on top of the trigger coming in contact with the front end of the groove (20), on the connecting bar. If the trigger is drawn back the tooth (36) is depressed, and the bolt can be withdrawn from the body. **Retaining arrangement.**

The sear G consists of a flat spring screwed on to the underside of the body. At its rear end is the bent (37) which projects through the tang into the boltway. **Sear.**

The trigger H works between two lugs on the under side of the body, and is pivoted by a pin which passes through them and through the hole (38) in the trigger. On its top end is the retaining tooth (36), which passes through the body into the boltway. The sear passes through a slot in the upper end of the trigger. When the trigger is drawn back the upper face of this slot bears down on the sear and depresses it. **Trigger.**

The interrupter I consists of a plate (39), a flat spring (40), and a tooth (41). The spring is secured to the outside of the body by means of a screw passing through its rear end. The plate (39) partly passes through a longitudinal slot in the left side of the body, and its inner edge enters the boltway. The projection (42) bears against the outside of the body and prevents the plate from entering too far. When the bolt lever is raised, the inner edge of the interrupter lies in the groove (13), in the bolt, and the tooth (41) enters the magazine through a slot in the top of its left side, and bears upon the second cartridge from the top, which it prevents from rising. When the bolt lever is turned down, the cam-shaped surface of the groove (13) bears on the edge of the interrupter at (43) and presses it outwards, so that the tooth (41) no longer holds the cartridge down. The projection (44) on the edge of the interrupter works in the groove (27), in the bolt-head, and, on the bolt being drawn back, strikes the base of the cartridge and ejects it. The action of the interrupter is as follows. On pressing cartridges into the magazine, the rims and bodies of the cartridges press the interrupter outwards, and so pass by it into the magazine, but the cartridge next below the top one, is always held down by the tooth (41), until the top cartridge has been pushed into the magazine and the bolt lever turned down. This arrangement prevents double loading, for after the top cartridge has been loaded into the chamber, the next cartridge cannot rise until the bolt lever has been turned down, and the claw of the extractor has got hold of the rim of the cartridge, which must then be extracted when the bolt is drawn back. **Interrupter.** **Ejector.**

On turning up the bolt lever, the bolt, bolt-head, and extractor revolve together, the tooth (31), on the cocking piece, **Action of the breech mechanism.**

works along the inclined face of the recess (9) in the bolt and drops into the recess (10). This draws back the striker and partly compresses the mainspring. The tooth (33) moves in the clearance (11) on the bolt, but does not touch the latter. At the same time the front of the rib (7) travels along an inclined plane on the body at (6), and forces the whole bolt back, effecting the primary extraction. As the bolt is being rotated the edge (43) of the interrupter works into the deepest part of the groove (13) in the bolt, and the tooth (41) enters the magazine and bears upon the top of the second cartridge from the top. On the bolt being drawn back the claw of the extractor withdraws the empty case from the chamber, until the base of the case strikes the projection (44) on the interrupter, when the case is ejected to the right. The backward motion of the bolt is then stopped by the tooth (36) on the trigger meeting the end of the groove (20) in the connecting bar. On pushing forward the bolt, the bottom edge of the bolt-head pushes the top cartridge forward into the chamber. When the rib (7) meets the inclined plane on the body at (6), the stud (30) on the cocking piece also meets the bent of the sear (37), and the lugs on the bolt-head (25) arrive at the cam grooves in the body.

On turning down the bolt lever, the lugs (25), moving along the cam grooves into their seatings (26), draw the bolt forward and complete the compression of the mainspring. The edge (43) of the interrupter is forced outwards by the cam groove (13) on the bolt, and the tooth (41) is withdrawn from the magazine, permitting the column of cartridges to rise up against the bottom of the bolt.

On pressing the trigger, the top of the slot in the trigger presses on the sear and depresses the bent (37) from in front of the stud (30) on the cocking piece. The latter and the striker then fly forward under the action of the mainspring, and fire the cartridge, the tooth (31) entering the recess (9) in the bolt.

Magazine.

The magazine (45), which holds five rim cartridges in a single column, is made in one piece with the trigger guard (46). The left side is cut away at (47) to admit the tooth (41) of the interrupter. The bottom of the magazine is closed by a trough-shaped plate (48), at the front end of which is a curved slot (49). The magazine is held in position by the screw (50) passing through the slot (49), and at its rear end by the claw (51), which passes through a slot in the plate (48) and supports it. This claw is on the end of a flat spring, screwed to the body at (52).

The cartridges are fed up by a lever (53), pivoted on a pin (54) above the slot (49). This lever is pressed upwards by a flat spring, the rear end of which is screwed to the plate (48). On the outer end of the lever a platform (56) is pivoted, and is pressed upwards by the flat spring (57), which fits in an undercut groove in the lever (53). At the front end of the lever is a projection, which partly closes the groove (49), but by depressing the lever the projection is raised, and the bottom of the

magazine can be detached, after the rear end has been released from the catch (51), without removing the screw (50).

The five cartridges are carried in a charger (see Plate LXII), stamped out of sheet steel, in which they are held by two small tongues folding over on to the end cartridges. To charge the magazine, the charger is placed into the recess cut for it in the bridge of the body, and the cartridges forced out of it by the pressure of the thumb. The charger, when empty, must be removed by hand. There is no cut-off, and the rifle can only be used as a single loader when the magazine is empty; it can be replenished at any time by the introduction of one or more single cartridges. The cartridges are placed in the charger, the centre one standing on the rims of the cartridges on either side of it, which, in their turn, stand on the rims of the two end ones. Charger.

The stock is in one piece, with fore-end grooves for the thumb and fingers of the left hand. The stock, trigger guard, and body are joined together by two screws (58) (59), which connect the ends of the trigger guard to the ends of the body. There is a full length rod groove, with a nut let into the rear end, for the cleaning rod to screw into. The thin wooden handguard extends from the upper to the lower band, and is lined at both ends with sheet brass, secured by three copper rivets in each case. Two tongues project from the lining at each end, and fit in grooves cut for them in the bands. Stock.

There are two bands, each of which is clamped to the fore-end by means of screws passing through the ends of the bands. Each of these screws is only threaded near the head, and has a button riveted on to the end of the plain part of the stem, so that on unscrewing, the band is tightened up (see figure J, Plate LI). One sling swivel is pivoted to the upper band screw, and the other to the screw (50) which passes through the magazine. Bands and swivels, &c.

The front end of the stock is covered by a small plain nose-cap, fastened by a screw passing through it from side to side. The butt plate is of sheet steel, bent over the heel of the butt, and fastened by two screws. Nose-cap and butt plate.

The full length cleaning rod is carried in the rod groove in the fore-end, and screws into the nut in the end of the groove. One end of the rod is provided with a button larger than the bore, in which there is a hole at right angles to the rod. This is probably for cleaning the chamber. The other end of the rod is threaded for a jag or brush. Cleaning rod.

The bayonet is browned all over, it is of + section and is attached to the rifle by means of the old-fashioned bayonet joint locking ring. It fits very firmly on to the barrel, and is always carried fixed, no scabbard being supplied. The blade lies close to the right side of the barrel, and is set at a slight angle so that its axis produced would pass through the small of the butt. The end of the bayonet is chisel shaped, and can be used as a screwdriver for stripping the rifle. Bayonet.

For weights and dimensions, see Table IV, Appendix.

SPAIN.

Mauser 7 m.m., ·276-inch Pattern, 1892.

See Mauser rifles, page 42.

SWITZERLAND.

Schmidt-Rubin 7·5 mm. ·295-inch, Pattern 1900.

This pattern is shorter and lighter than pattern 1893, the magazine holds six rimless cartridges in place of twelve, and the bolt, which is a straight pull, differs in having the lugs at the forward end of the locking sleeve.

Barrel. The barrel is strongly reinforced where it screws into the body. The diameter is reduced in two steps just in front of the end of the chamber, it then tapers to the muzzle, a slight swell being left for the foresight ring and the barrel sleeve. This latter component is peculiar to the Schmidt-Rubin rifle, and consists, see (1) Fig. A, of a tube of copper alloy which fits the swell on the barrel, just freely enough to allow the latter to pass through it when expanded by heat. The sleeve is firmly gripped between the fore-end and handguard.

Sights. The barleycorn foresight is dovetailed at right angles to the axis of the barrel, into its block, which forms part of a ring, soldered to the swell on the barrel. The backsight is placed close to the breech end of the barrel. The bed is screwed on to the barrel, and is formed with a ring which goes round the latter. The leaf (2) is pivoted on the screw (3) at its forward end, and works between the high sides on the bed. On the left side of the leaf is a spring arm (4) pivoted on the screw (3), and ending in a roughened finger piece (5), the spring being so set as to press outwards. On the side next the bed this arm is bevelled off and engages in the ratchet-shaped grooves cut on the inside of the bed for every 100 metres from 300 to 1,200 metres. A longitudinal rib on the inner side of the arm fits in a groove on the side of the leaf. The rear end of the leaf is turned up at an angle of 45°, and the V for aiming is cut in it. The graduations from 300 to 1,200 metres are marked on the top of the left side of the bed. Outside the bed on the left the graduations for 300, 500 and 1,000 metres are marked.

Body. The body, behind the magazine way, forms a complete cylinder (6) for a length of $4\frac{1}{4}$ inches, and is thus of considerable length. On the right side, and forming part of the body, is a smaller cylinder (7) opening into the larger one. A slot in the bottom of this cylinder admits the tooth (44) of the retaining bolt. A short groove is cut at the bottom of the cylinder (6) for the striker stud (33), a vertical slot being cut at the bottom of this groove for the sear bent (49). On

SWITZERLAND. SCHMIDT RUBIN 1900.

Plate LII.

To face page 95.

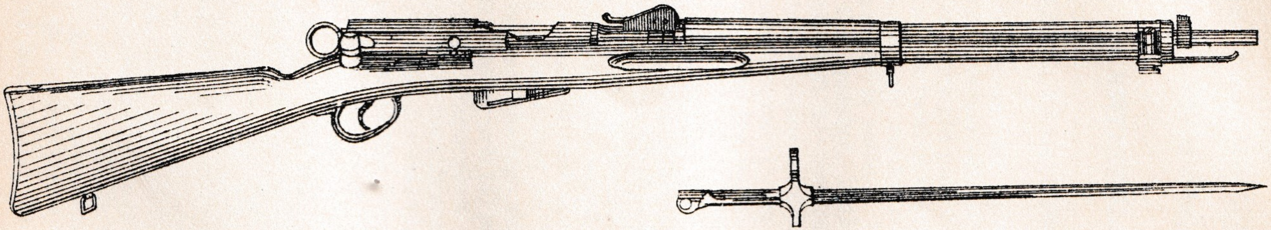

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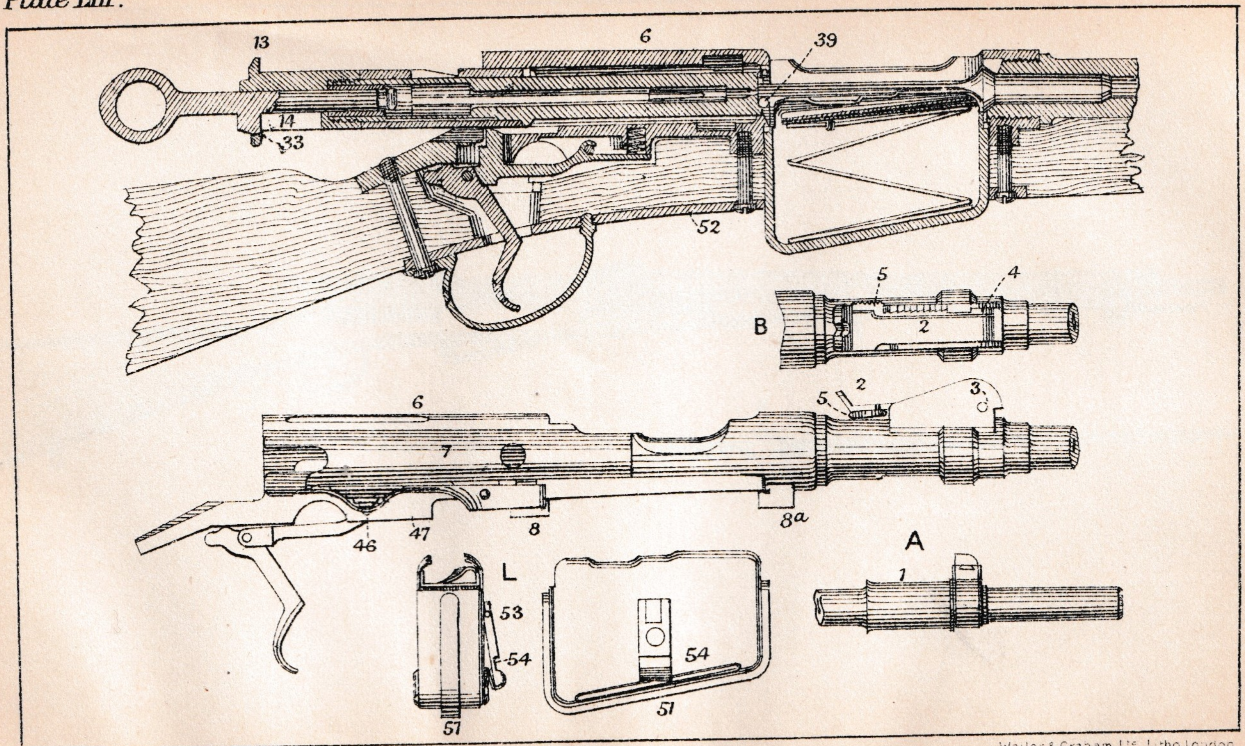
Plate LIII.

SWITZERLAND. SCHMIDT RUBIN, PATTERN 1900.

To face page 95



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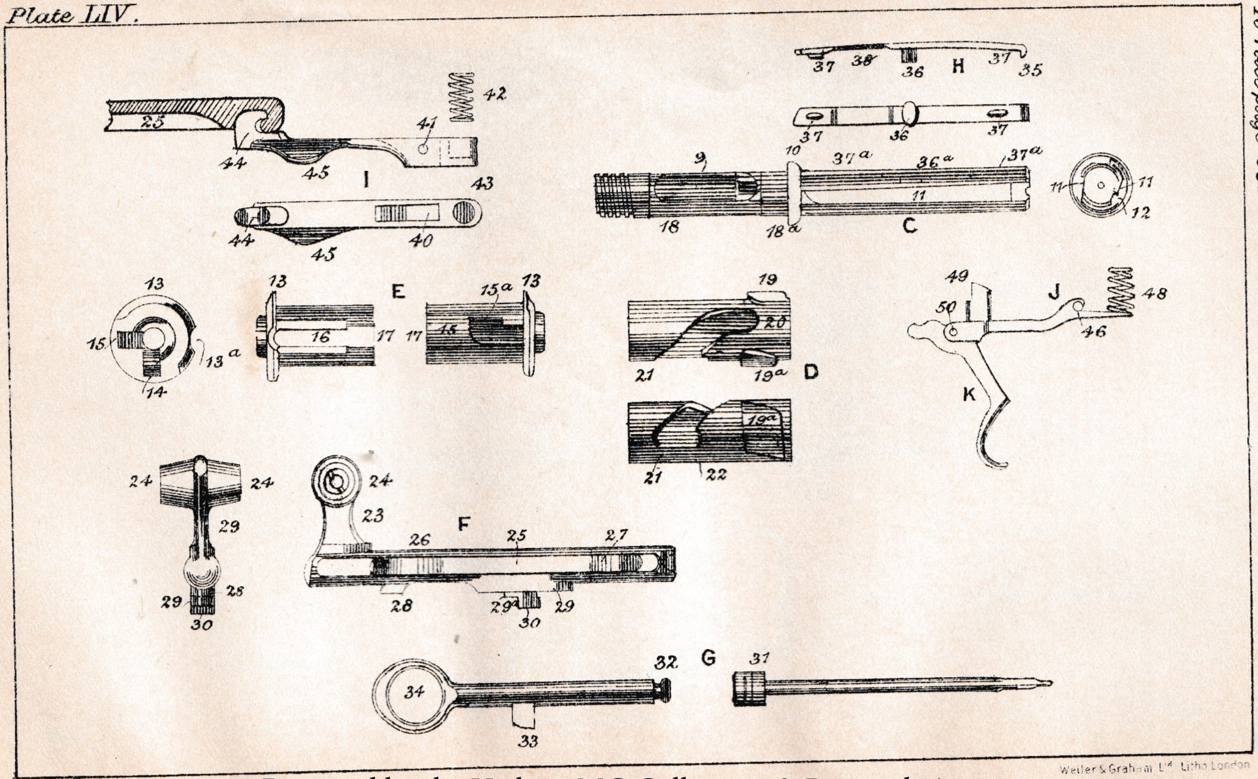
SWITZERLAND, SCHMIDT RUBIN, PATTERN 1900.

Plate LIV.

To face page 95.



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each side of the interior of the cylinder (6) are longitudinal grooves for the bolt lugs (19, 19*a*). These grooves communicate by means of diagonal grooves with the lug seatings, which are cut on a screw pitch. The rear part of the body forms a short tang.

The bolt which is made up of the bolt cylinder C, the locking sleeve D, and the bolt cap E, is operated by means of the action rod F. The bolt cylinder is bored out from the rear for the striker and mainspring, and is slotted, on the right side at (9), to admit the tooth (30) of the action rod. A circular flange (10) affords a bearing for the front end of the locking sleeve D. In front of this flange the bolt cylinder is grooved on both sides at (11) to allow it to pass through the turned-in sides of the magazine L. Bolt.

On the left is a deeper groove (12) for the ejector (39). On top a little to the right is a flat for the extractor. The front end of the bolt cylinder is permanently screwed in. The face of the cylinder is recessed for the head of the cartridge, but the rim of the recess is not cut away at the bottom to allow the heads of the cartridges to rise up at once under the claw of the extractor when loading, therefore double loading is possible. The bolt cap E screws on to the rear end of the bolt cylinder. It is bored out for the striker, and has a shoulder inside, against which the rear end of the mainspring bears. At the rear end is a broad flange (13), with a clearance (13*a*) for the action rod. It is slotted out at (14) for the striker stud (33). At right angles to this slot is the safety slot (15) for the striker stud. On the right side is a rib with an undercut groove (16) for the stud (28) on the action rod F. The front end (17) forms a bearing for the rear end of the locking sleeve D. The locking sleeve fits loosely behind the flange (10) on the bolt cylinder, the diameter of the latter being slightly reduced from (18) to (18*a*) to lessen friction. At the front end are the two lugs (19, 19*a*), which resist the backward pressure of the cartridge on firing. The top lug (19) is slightly in advance of the other, and their front and rear faces are cut with a screw pitch. A helical slot for the stud (29*a*) on the action rod runs from (20) to (21). A recess (22) in this slot affords a seating for the stud (29*a*) when the action rod is drawn back. The action rod F works in the cylinder (7) in the body. On the right, at the rear end, is a lever for operating the rod, to the end of which lever, on either side, vulcanite knobs (24) are fixed by screws. Underneath is a groove (25) for the tooth (44) of the retaining bolt. Within this groove are two projections (26) (27), against which the tooth of the retaining bolt bears, in the open and closed positions, and holds the action rod steady. On the left a dovetail stud (28) fits in the undercut groove (16) on the bolt cap E. The rib (29) works in the slot between the cylinder (6) in the body, in which the bolt works, and the cylinder (7) for the action rod. The stud (29*a*) works in the helical groove (20) (21) in the locking sleeve, which it causes to

revolve. The stud (30) enters the bolt cylinder through the slot (9), and lies in front of the head (31) on the striker.

Striker. The striker G is divided into two parts, the front part has a short point at the front end, and a head (31) at the other. The rear part has a button (32) at one end, which fits into a suitable recess in the head (31), and underneath carries the striker stud (33), which works in the slot (14) in the bolt cap. The striker can be drawn back by means of the ring (34) on the rear end.

Mainspring. The mainspring consists of 15 coils of flattened steel wire ·06 × ·04 set to a length of 2·3 inches.

Extractor. The extractor, H, is a flat spring terminating in the usual claw (35), projecting beyond the face of the bolt. It is provided with a stud (36) with circular stem and oval head. Near each end are two small projections (37). To fix the extractor place the stud (36) in the oval hole (36*a*) in the bolt cylinder, with the extractor at right angles to the latter, then turn the extractor parallel with the bolt, and the head of the stud will lock under undercut grooves, and the projections (37) will spring into seatings (37*a*) cut for them. A shallow recess (38) enables the end to be raised when removing the extractor.

Ejector. The ejector (39) is a pin with a broad head and flat point, which passes through the left side of the body. It is secured by a keeper screw.

Retaining bolt. The retaining bolt, I, is pivoted underneath the small cylinder (7), on a projection, which fits into the slot (40), through which the axis pin (41) passes. At the front end is a spiral spring (42) which fits in the hole (43), and bears against the bottom of the cylinder (7). On the rear end is a tooth (44), which is pressed upwards, by the spring (42), into the groove (25) in the action rod. When the latter is fully drawn back this tooth locks into the front end of the groove as shown. To withdraw the bolt push it forward slightly, and depress the tooth by pressing on the thumb piece (45).

Sear. The sear, J, is pivoted on the pin (46) in a slot in the projection (47) under the body; its front end is pressed down by the spiral spring (48), which raises the sear bent (49), through a slot in the bottom of the body, into the groove for the striker stud (33).

Trigger. The trigger, K, is pivoted on the pin (50) in a fork at the end of the sear.

Action of the mechanism. The bolt is worked by a straight backwards and forwards motion imparted by the action rod, F. In the first motion of drawing the action rod to the rear the tooth (29*a*) moves in the straight part of the slot (20) of the locking sleeve; the tooth (30) bearing against the head (31) of the striker begins to draw it back, and the projection (26), in the groove of the action rod, depresses the tooth (44) of the retaining bolt, I. On continuing the backward motion, the tooth (29*a*), which is constrained to move in a straight line, on account of the rib (29) moving in the slot between the two cylinders (6) and (7), bears against the curved part of the slot (20), and rotates the sleeve,

turning the lugs from in front of their seatings into the diagonal grooves in the body. On account of the lugs and their seatings being cut on a screw pitch, the entire bolt is withdrawn about $\frac{1}{16}$-inch; this forms the primary extraction. The tooth (29*a*) has now got to the back end (21) of the slot in the locking sleeve, and has drawn the striker fully back. The whole bolt is now free to come back; as it does so the lugs (19 and 19*a*), on the bolt sleeve, pass along the diagonal grooves and further rotate the locking sleeve, until the recess (22) slips in front of the stud (29*a*). The latter is pressed forward into this recess by the head (31) on the striker, actuated by the mainspring. On continuing the backward motion, the projection (27) in the action rod groove depresses the retaining bolt tooth, and the latter then strikes the end of the groove (25) and arrests the backward motion. The dovetailed stud (28) on the action rod working in the groove (16), on the bolt cap, serves to keep the action rod parallel with the bolt.

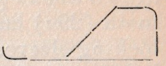
On pushing forward the handle of the action rod the retaining tooth (44) is depressed by the projection (27), and the whole bolt mechanism moves forward. When the lugs (19, 19*a*) pass down the diagonal grooves the locking sleeve is rotated, so that the recess (22) no longer retains the stud (29*a*). When the flange (13) on the bolt cap arrives within $\frac{1}{16}$-inch of the cylinder (6) on the body, the sear bent (49) engages the striker stud (33), and the lugs on the bolt cylinder have arrived at the entrance to their seatings. On pushing home the action rod the stud (29*a*) passes along the groove (21) (20) and revolves the locking sleeve, placing the lugs (19, 19*a*) in their recesses, and fully closing the bolt. As the bolt is finally closed the extractor claw springs into the groove round the head of the cartridge, which has been pushed forward out of the magazine by the bolt, and the retaining bolt tooth (44) rises behind the projection (26) in the action rod groove, and prevents the action rod from slipping back.

Safety arrangement.

By drawing back the striker, and revolving it so that the striker stud (33) points to the left, the latter enters the safety slot (15), which is shorter than the slot (14). The point of the striker cannot then reach the cap of the cartridge, and the bolt cannot be drawn back, as the rear face of the stud (33) is engaged by the shoulder (15*a*) in the groove (15) in the bolt cap.

Magazines.

The magazine, L, is made of sheet steel, and holds six rimless cartridges. It is strengthened by a steel strap (51) brazed on. In the bottom, on either side, are two small openings for the escape of dust, which, however, is also liable to find its way in through these openings. The magazine is inserted through an opening in the trigger guard plate (52). A small lever is pivoted on a pin (53) passing through a projection on the right side of the magazine. A groove (54) in this lever engages the trigger guard plate, and retains the magazine in position. The lever is pressed outwards by a small spiral

spring underneath its lower end. The top edges of the magazine are partially turned over, and thus prevent the two columns of three cartridges from being ejected by the magazine spring. The platform is of sheet steel bent thus  with one side higher than the other, so as to raise the cartridges in one column, and present the cartridges in the two columns alternately at the opening in the top of the magazine. The platform, which can be slipped out of the magazine to the rear, is pressed upwards by a zig-zag wire spring with three coils.

Charger.

The magazine is filled either by the insertion of single cartridges or from a charger (see Plate LXIII), containing six cartridges. The charger is of papier maché, the bottom edges being protected by a tinned iron strip having tongues, two on either side, which are bent over so as to retain the cartridges. To fill the magazine the charger is placed vertically over it, mouth downwards, the fingers of the right hand gripping the magazine underneath. The cartridges are forced downwards, out of the charger, by the pressure of the thumb, which works in the broad slot cut for it in the papier maché portion of the charger.

Guard.

To the guard, which is a long one, the front end of the trigger guard proper is screwed, and the rear end is attached by the long screw which passes up through the stock into the tang. The guard, stock and body are also joined together by two screws that pass up through the guard into the projections (8 and 8*a*) under the body.

Stock.

The stock is in one piece, with grooves for the fingers and thumb of the left hand. The barrel groove fits the barrel as far as the front of the backsight bed, from thence to the barrel sleeve (1) it is about $\frac{1}{4}$-inch more in diameter than the barrel so that the fore-end is quite clear of the latter. The barrel sleeve fits the fore-end groove, and is firmly clamped by the upper band, between the fore-end and the handguard. The latter is secured to the fore-end by the upper and lower bands. The rear end of the handguard is bound by a steel band secured by two rivets, and fits under projections on the backsight bed. The barrel groove in this part of the stock is considerably broader than the barrel, therefore the stock does not touch the latter.

Bands.

The upper band fits in a shallow groove in the fore-end and handguard; it is made in two pieces with a hinge on the left side. The two ends on the right are drawn together by means of a screw. Underneath is the bar for the attachment of the sword bayonet, and a short rod with upturned end for piling arms screwed in and secured by a fixing pin. The lower band is fixed to a spring let into the underside of the stock; it is divided on the left, the two ends being drawn together by a screw, and a sling swivel is attached to the underside. The other sling swivel is attached to a small plate, secured by two screws,

Plate LV.

UNITED STATES. SHORT MAGAZINE RIFLE, ·3 INCH, PATT. 1903.

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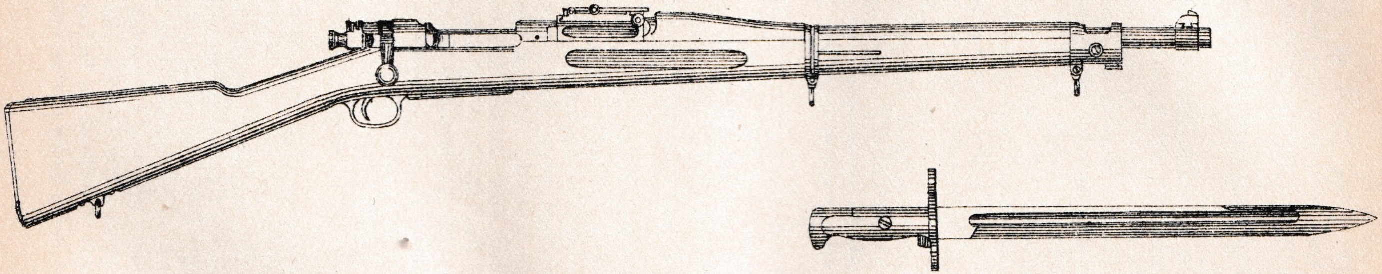

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UNITED STATES. SHORT MAGAZINE RIFLE, 3 INCH, PATT. 1903.

Plate LVI.

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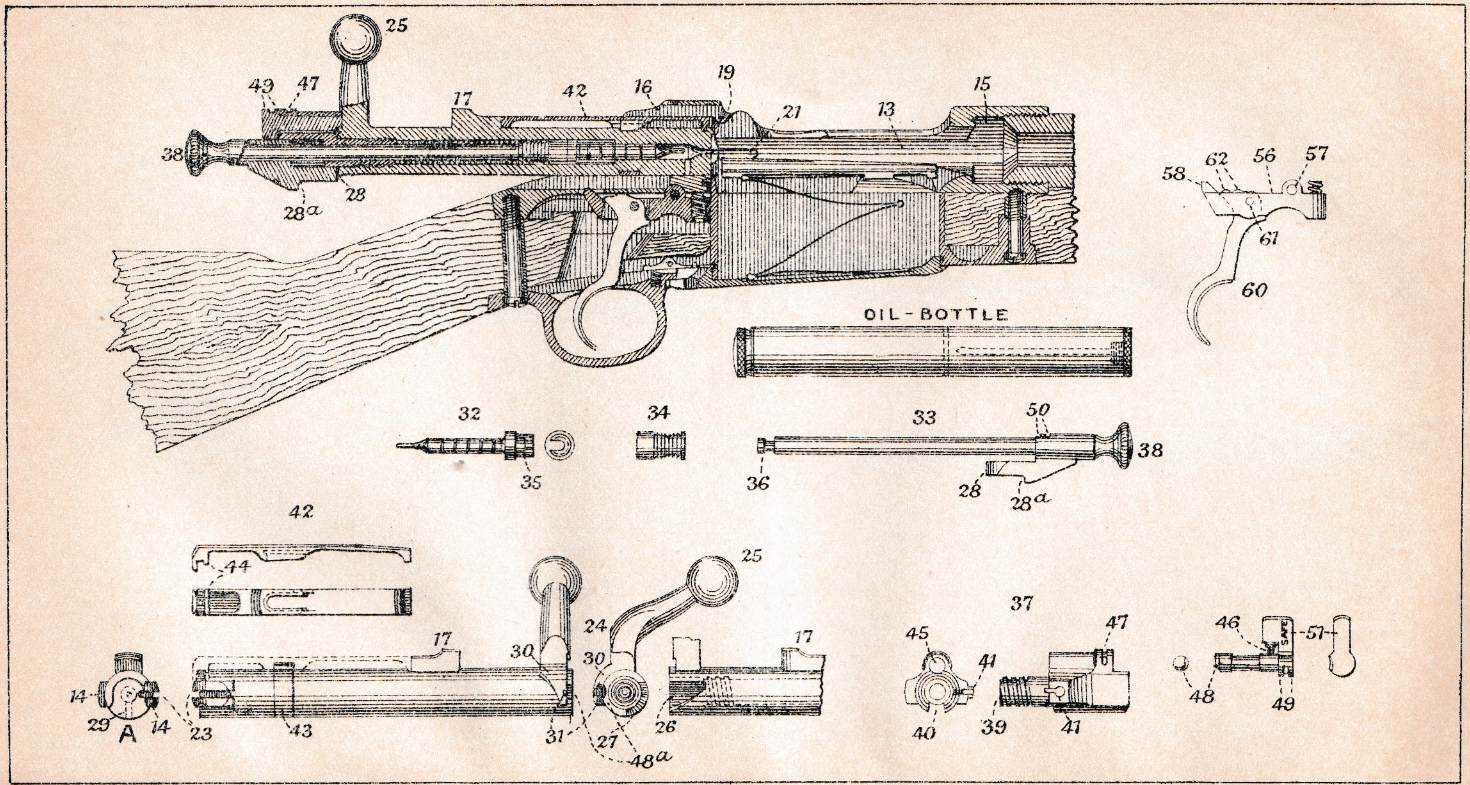

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Plate LVII.

UNITED STATES. SHORT MAGAZINE RIFLE, ·3 INCH, PATT. 1903.

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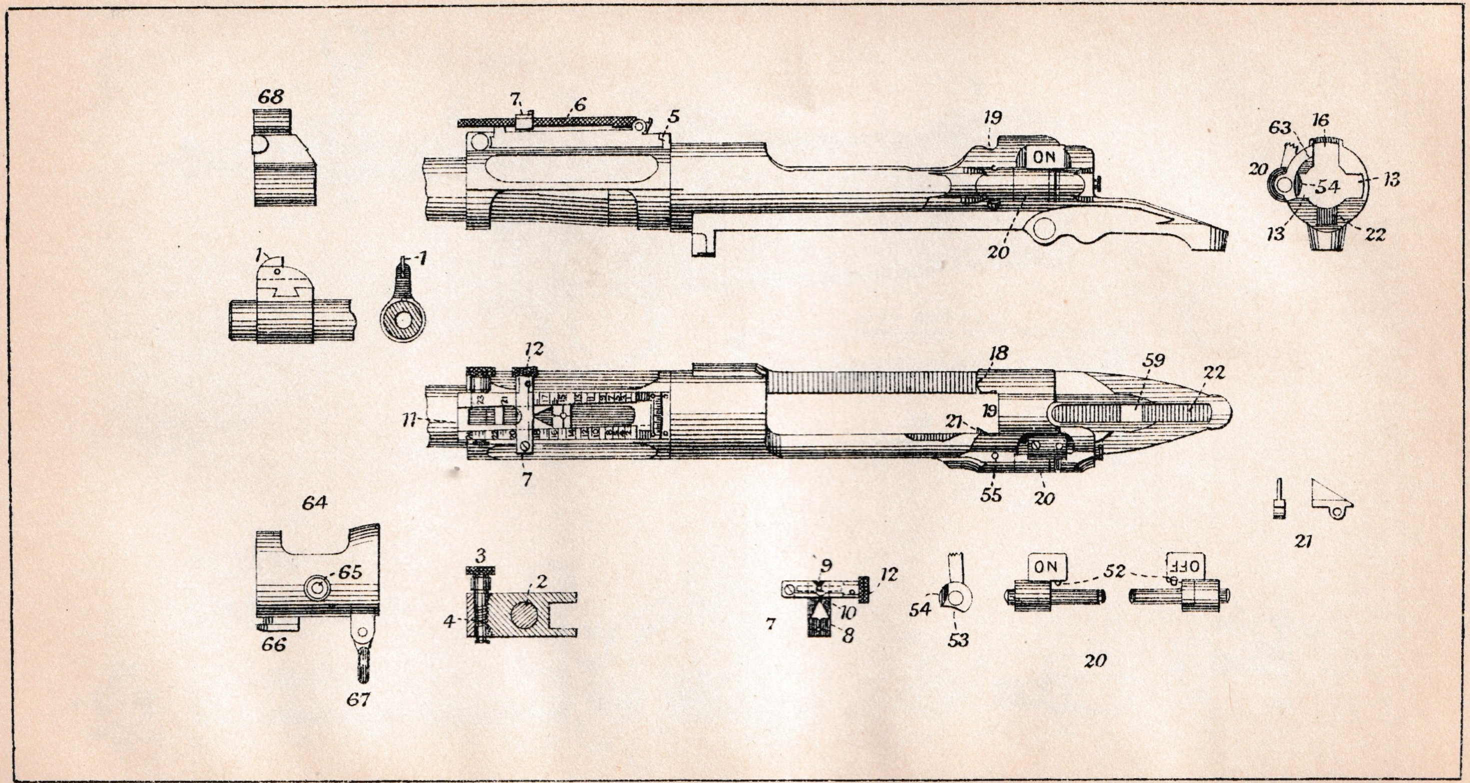

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underneath the butt. The sheet steel butt plate is attached by two screws; its sides and toe are much rounded off.

The blade of the sword bayonet is of + section; there are no wooden grips. A projection for the bolt and spring is brazed on to the rear end. The crossbar, with the usual barrel ring, is shrunk on to the blade. The sword bayonet is browned all over. Sword bayonet.

For weights and dimensions, see Table IV, Appendix.

TURKEY.

Mauser, 7·65 *mm.*, ·301-*inch*, *Pattern* 1890.

See Mauser rifles, page 42.

UNITED STATES.

Short Magazine Rifle, 7·62 *mm.*, ·3-*inch*, *Pattern* 1903.

The action of this rifle is a modification of the Mauser.

The barrel has a reinforce over the chamber, and tapers from a point 2 inches in front of the body, where there is a slight shoulder, to the muzzle. Barrel.

The foresight is a narrow hardened steel plate (1) which is pinned in a longitudinal groove in the foresight block. The backsight bed is in two parts. The lower half is in the form of a sleeve which butts against the body. The upper half is turned on a pivot (2) on the lower half by means of a worm with a milled head (3) working in a worm gear (4) in its forward end; its rear end moves in an undercut groove (5) in the lower half and has the windgauge scale cut on it, two zero lines being cut on the fixed lower bed. The leaf (6) is pivoted near its rear end, and is controlled by a flat spring dovetailed into the bed. The sight is used with the leaf up. The leaf is graduated in hundreds of yards on alternate sides from 100 to 2,400 yards, each hundred being sub-divided into 25 yards on the opposite side. The slide (7) is in two parts, the slide proper and a plate (8) in which are two U's, and a peep sight. This plate is held to the slide by a stud which works in a horizontal groove in the face plate of the slide. It moves in grooves cut in the front of each side of the leaf. These grooves are slightly inclined to the left, from bottom to top, to allow for drift Sights.

The slide is provided with three U's, and a peep sight. One U (9) is on top (leaf raised), one in the base of a triangular opening under the bar, and one (10) on the bar for use with the leaf down to give 400 yards elevation; another U (11) in the top of the leaf gives an elevation for 2,500 yards. A clamping screw (12) in the right of the slide prevents it slipping on the leaf. The slide may be removed by detaching a plate on its face. This plate, dovetails on which fit into horizontal undercut grooves in the slide, is fixed with a screw and also by the pin which retains the clamping screw.

Body. The body screws on to the breech end of the barrel in the usual manner, and is cut away on the right side of the boltway to facilitate ejection and loading. The lower part of the body is cut through to form the upper portion of the magazine. Two grooves (13) are cut on either side as guides for the locking lugs (14) on the bolt. These grooves terminate in a recess (15), cut in rear of the chamber, in which the lugs lie when the bolt lever is turned down in the ready position, thus locking the bolt to the barrel. The rear of the body is cylindrical in form, and has a groove (16) cut in the top of its interior to afford clearance for the resistance lug (17) on the bolt while the right of the cylindrical portion forms a resistance shoulder (18) for this lug, the front being cut to form a charger guide (19). In the left of the body is a retaining bolt (20) and the ejector (21). In the interior of the cylindrical portion in rear a cam is cut (63), which causes primary extraction. The rear end of the body forms a tang, which has a longitudinal groove (22) for the cocking-piece stud.

Bolt. The face of the bolt cylinder, A, is recessed for the base of the cartridge, which has a rim. There is no separate bolt-head. Two locking lugs (14) are situated at the head of the bolt. The left-hand lug ends in a claw which, being opposite the extractor which lies over the other lug, helps to support the cartridge. A longitudinal slot (23) is cut on the left through which the ejector works. On the right side, when the bolt is closed, is a solid lug (17) which bears against the shoulder (18) of the body, and assists in taking the shock of recoil. The lever (24), terminating in a knob (25), is at the rear end of the bolt cylinder.

A cam-shaped recess (26) is cut in the back of the bolt, and close to it is a small groove (27) for the point (28) of the cocking stud to rest in when the breech is open. A gas-escape hole is bored into the striker way at (29). A flange (30) runs partly round the rear end of the bolt. A recess (31) is cut in the back of this flange for the spring catch of the bolt plug.

Mainspring. The bolt is bored out from the rear for the mainspring, which is of ·05-inch wire, with 39 coils set to a length of 5·25 inches, and the bolt has an internal square screw thread into which the bolt plug screws.

Striker. The striker is in three pieces and consists of the firing-pin (32), the rear portion (33) on which the cocking piece is

formed, and a collar (34), which connects the two. The firing-pin is bored out in rear and has a circumferential groove cut (35) in the inside; a head (36) is formed on the rear portion of the striker which passes through an opening in the side of the firing-pin and lies in this groove; the rear portion and firing-pin are kept together by the collar (34) which is pressed forward over the joint by the mainspring. The rear portion passes through the bolt plug (37), the front end of which forms the rear bearing for the mainspring. The cocking piece has only one bent (28*a*) and has a milled head (38) for cocking by hand.

The striker passes through the bolt plug (37), which screws into the rear portion of the bolt, and against which the mainspring bears at (39). The plug is bored out from the rear for the cocking piece, and has a slot (40) in it underneath, for the cocking toe to travel in. On top it extends over the bolt. A small spring catch (41) on this portion engages in a recess (31), in the flange of the bolt, and prevents the bolt plug from unscrewing when the breech is open. Bolt plug.

The extractor (42), a long flat spring, is fixed by a dovetail to a split ring (43) which works in a cannelure cut round the bolt. A projection (44) on the front of the extractor works in another small cannelure, cut in the front of the bolt, and prevents the extractor being drawn to the front. The bolt is thus free to revolve without the extractor during primary extraction, as the extractor is held in the groove (13) on the right side of the body. Extractor.

The stem of the safety bolt fits into the cylindrical hole (45) in the bolt plug. There is a small spring stud (46), under the forward end of the thumb piece, which works in a groove (47) in the bolt plug over which it projects. The front end (48) of the stem is cut away in two places; when the thumb piece is turned over to the right (safe), the part of the stem not cut away, turns into a recess (48*a*) in the rear of the bolt, thus preventing the bolt lever being raised. The rear portion has two circumferential ribs (49) which are cut away in one place; these ribs turn into recesses (50), cut in the cocking piece, and prevent the latter going forward except in the position "Ready." Thus, if the thumb piece (51) is turned over to the left (ready), the rifle can be fired and the breech opened for loading. If the thumb piece is placed upright, the breech can be opened, but the rifle cannot be fired. If thumb piece is put over to the right (safe), the rifle cannot be fired, and the breech cannot be opened. Safety bolt.

The retaining bolt (20) lies longitudinally in a recess in the left side of the body. A spring stud (52), similar to that in the safety bolt, limits its motion. The stem is cut away in two places longitudinally, in one place (53) for its whole length, and in the other (54) for a limited amount of its length; if the thumb piece is put down (off), the part of the stem, which is not cut, prevents the bolt being withdrawn sufficiently far to enable the cartridges to rise from the magazine, as the left lug of Retaining bolt.

the bolt comes against stem of safety bolt which projects into the boltway. If the thumb piece is put right up (on), the portion of the stem, partly cut away, projects into the boltway and allows the bolt to come back far enough to clear the cartridges in the magazine. If the thumb piece is put horizontal the side of the stem, completely cut away, is inside and the bolt can be withdrawn.

Ejector.

The ejector (21) fits in a slot on the left of the boltway, and is pivoted at its rear end. On drawing back the bolt the point, which is a thin blade, passes through the slot in the left bolt lug. The rear of the latter then comes against the broader part of the ejector in rear, turns it on its pivot (55), and forces the point inwards under the base of the cartridge case, which is then ejected by the further movement of the bolt to the rear.

Sear.

The sear (56) is pivoted by means of a pin (57), to two ears formed on the underside of the body. Its nose (58) projects into the slot (59) in the tang of the body, and is pressed upwards by a small spiral spring, fitting in a recess at the forward end.

Trigger.

The trigger (60) is pivoted to the sear by the pin (61). It has two projections (62), on its upper surface, which bear in succession against the underside of the body, and produce the double pull-off, fully described in the Austrian Mannlicher.

Action of the bolt mechanism.

On raising the bolt lever the bolt is revolved to the left, the extractor being held immovable by the groove (13) on the right of the body, till the flange (30), on the rear of the bolt, comes in contact with the cam (63), in rear of the cylindrical portion of the body, and the bolt is forced slightly to the rear taking the extractor with it and causing primary extraction. On drawing back the bolt the lug (14) on the left strikes against the rear of the ejector, forcing the point inwards; on drawing the bolt further to the rear the base of the cartridge strikes this point and is ejected.

Cut-off.

There is no cut-off in the ordinary sense, the retaining bolt acting as such by preventing the bolt-head clearing the cartridges in the magazine when set to "off," see above.

Magazine.

The magazine is the same as that in German, Spanish, and Turkish Mausers described previously on page 48, and shown in figures Q and R, Plate XVI.

Stock.

The stock is in one piece without pistol-grip, but with fore-end grooves for the fingers and thumb of the left hand. The stock and body are secured together by two screws passing up from underneath, through the ends of the trigger guard. There is a handguard extending from the rear end of the barrel to the lower band. This is secured by two bands which encircle the barrel.

Bands and swivels.

The upper band (64) is secured to the fore-end by a screw (65) passing through it. It is longer than usual, and has a strap at either end, passing over the barrel. On its underside in front there is the usual sword-bar (66), and in rear a piling swivel (67) similar to that on the Lee-Enfield Rifle. On the

lower band is pivoted a sling swivel. The other sling swivel passes through a boss on a plate, which is screwed to the underside of the butt. No cleaning rod is carried in the rifle.

The lower band is held in place by a spring let into the fore-end. A front sight protector (68) is provided, made of folded and tempered sheet steel.

The sword bayonet, pattern 1905, has a knife-shaped blade about 16 inches long, sharpened on one side for its whole length, on the other side for 5 inches from the point. Sword bayonet.

The crossbar, grips, and pommel, are similar to those of the bayonet used with the Lee-Enfield Rifle.

A scabbard catch is provided, operated by the same spring as the bayonet catch, the thumb piece of which is on the underside of the grip just behind the guard.

For weights and dimensions, see Table IV, Appendix.

CHAPTER V.

Comparison of the Principal Components of Modern Military Rifles.

Barrels.

The different forms of rifling now used are described in Chapter II and the length and weight of the barrel is discussed in Chapter III. Barrels used to be longer than they now are—

I. On account of the importance of length in bayonet fighting, which was then much more likely to occur than it is now in the days of long range magazine rifles.

II. Because formerly when firing in two or more ranks, a short barrel might wound or deafen the men in the front rank.

III. Because the efficiency of the powder was less, the windage was greater and the necessary velocity could not be attained in a short barrel.

The following table shows the decrease in length of the barrel in English and German breech-loading rifles:—

England.

	Year.	Inch Barrel.
Snider	1853	39
Martini-Henry	1871	33·2
Lee-Metford	1889	30·197
Short Lee-Enfield	1902	25·197

Germany.

	Year.	Inch Barrel.
Dreyse needle gun	1841	35·4
Mauser	1871	33·46
Mauser and Commission	1884	31·5
Rifle Pattern	1888	29·134
,, ,, ...	1898	29·05

Lightness, correctness of balance, and handiness are of great importance now-a-days as they tend to improve snap shooting, which appears likely to assume increased importance as the deciding factor in an action. The barrel must, however, have sufficient length, to give the requisite velocity without using an excessive charge, and to keep the sights sufficiently far from the eye and from each other, to allow of accurate aim being taken.

Barrels are thickest at the breech end, on account of the pressure of the gas falling as the bullet moves up the barrel.

The thickness of the barrel is always considerably more than the pressure of the service cartridge requires; if it were not so, any abnormal pressure, such as might be produced by a plug of dirt in the muzzle, or the envelope of a bullet in the bore, might lead to a burst barrel, and injury to the firer, instead of merely a bulge in the bore.

Various processes have been tried to make barrels stiffer and harder, so as to enable them to resist the friction of the envelope of the bullet, the erosion of the powder, the wear and tear of cleaning, and the effect of blows. The Marcotty system of rolling the barrel blank a great number of times, at a low heat, is used in Germany and elsewhere on the Continent; it has the effect of improving the physical properties of the steel. Some nations, such as Russia, oil-harden the barrel, by heating it in a bath of molten lead, and then pumping vegetable oil through it while suspended in a vertical position. In experiments carried out in the United States it was found that little if any increased resistance to tangential stresses, is given by oil tempering, at any practicable temperature, and that after firing 5,000 rounds from a neutral, and from an oil-hardened barrel, there was but little difference in the extent of the erosion.

On firing a rifle the barrel commences to vibrate before the bullet has left the muzzle (see Chapter III, Part II). This vibration exercises a very disturbing effect on the accuracy of the rifle, on account of the difficulty of ensuring that the fore-end shall influence the vibrations to the same extent at every shot. With the ·45 bore match rifle this difficulty was met by using a thick heavy barrel that did not vibrate easily, and by cutting short the fore-end where it is gripped by the left hand. In the Danish Krag Jorgensen, the Belgian Mauser, and the German pattern 1888, rifles, the barrel is surrounded by a tube which touches it at the breech and muzzle ends only. The advantages claimed for the barrel casing are—

1. It prevents the fore-end exercising a variable influence on the vibrations of the barrel.

2. A warped fore-end is less easily able to bend the barrel.

3. It affords a protection against blows.

4. It acts as a handguard.

5. The sights are brazed or soldered to the casing, the barrel, therefore, escapes this operation, which usually bends it slightly.

6. It obviates the disturbing influence on the shooting caused by the varying tightness of the bands.

The barrel casing was given up by Germany on introducing the rifle pattern, 1898. The following are found to be its disadvantages:—

1. To keep the weight within the necessary limits, the casing has to be made too thin to act as an efficient protector.

It is liable to get injured by blows, and the sights get out of alignment with the axis of the bore.

2. Rust is liable to set up within the casing.
3. It is more difficult to strip the barrel.
4. Increased expense in manufacture and repair.
5. The thin barrel is less able to resist abnormal internal pressure without bursting; and it vibrates to a greater extent.

The barrels of the German pattern 1898, the Spanish and Turkish Mausers, are turned down externally in steps, probably with the idea of breaking up the wave of vibration as it passes along the barrel.

The condition of the muzzle end of the barrel is most important. If it is unevenly cut in manufacture, or worn away at one side by the pull-through, the gas will escape unevenly round the bullet, and tend to upset it as it starts on its flight.

Sights.

The sights of a military rifle should be strong, simple, quickly adjusted, and not liable to be shifted by the jar of recoil. They should be capable of being quickly and accurately aligned, and should be correctly graduated and fixed upon the barrel.

Foresights.—The foresight usually consists of a barleycorn or blade dovetailed into the foresight block at right angles to the axis of the barrel (see Figs. 1 and 2). By adjusting the foresight to one side or the other, the rifle can be made to shoot correctly for direction. Barleycorns and blades of different heights are used by several nations, so as to be able to get the lowest elevation on the backsight correct, as minute variations in the stock and fit of the bolt may alter the jump of the rifle. When the lowest elevation is correct, the other graduations will be correct in normal weather, as they are definite heights above the lowest one. These heights are carefully worked out by repeated trial when the sighting of the arm is being settled. Another advantage possessed by adjustable foresights when compared with fixed ones, is that they can be hardened and tempered, so that they are much less liable to be injured by rough usage. If one does get injured it can easily be replaced by another.

The foresight is protected by a fixed hood forming part of the nose-cap which goes round the barrel and over the sight.

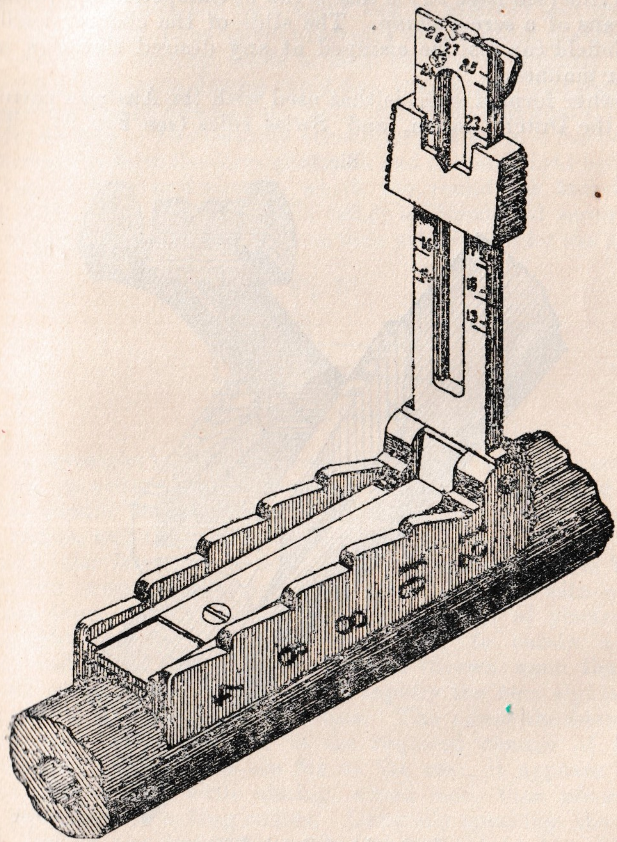
Backsights.—The form of backsight used in this country with the Snider, Martini-Henry, and with the Lee-Metford and Lee-Enfield magazine rifles, consists of a leaf, pivoted to the bed at the rear end and having at its front end a cap provided with a V for use at short ranges, with the leaf down. To adjust the sight, the slide is pushed forward and mounts the ramps on the bed. These ramps are in the form of steps in the Snider and Martini-Henry, each step representing an increase of elevation of 100 yards. In the ·303 rifles the ramps are curved, and slight increases or decreases of elevation can easily be given. The advantages of the steps are, that changes of elevation can be made by touch, without having to look at the figures on the side of the bed. For longer ranges the leaf is raised and aim is

taken over the V in the slide, the latter being set to the graduation lines on the face of the leaf.

For target shooting the slide of the ·303 magazine rifle can be turned over and aim taken over the straight edge, using the centre line to give direction. This enables an accurate aim to be taken; but it is not suitable for service, as the centre line is apt to get obliterated, and when it is in good order, it cannot be seen when shooting out of a casemate, or from under shady trees. In Continental arms a V only is used, the centre line being considered unnecessary.

Fig. 8 represents the backsight on the Russian 3-line rifle

Fig. 8.



Backsight of the Russian 3-line Rifle.

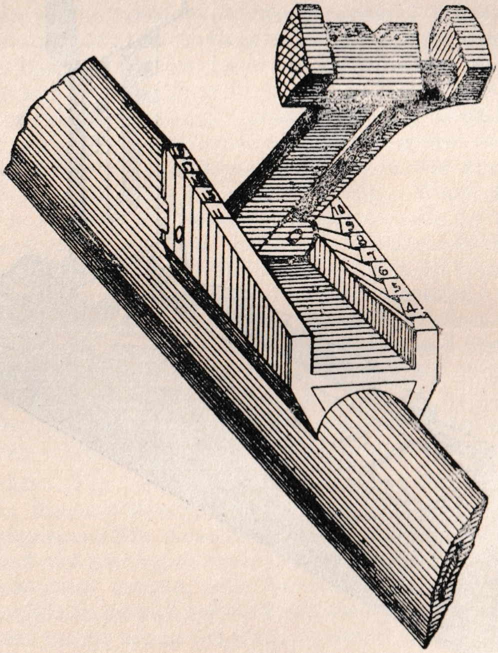
It is on a similar principle to that of the ·303, but the leaf is hinged to the front of the bed, and the ramps, which are cut in steps, come on the outside of the leaf, instead of through the opening in it.

The advantage of using ramps is, that a considerable movement of the slide may be given to effect the very small increase in elevation necessary for each 100 yards at the short ranges, and by giving the ramps a suitable curve the spaces between the graduations may all be made equal (see the short Lee-Enfield rifle sight, Fig. 13, page 111).

The slides of the Belgian, French, and Russian rifles, and the English long rifles maintain their position by friction only. The slides of the Austrian pattern, 1895, Danish, the Roumanian, Spanish, and Turkish rifles and English short rifles are kept in position by the tooth of a catch engaging in suitable notches cut for it in the leaf. The advantage of the slide of the United States rifle (see page 99) is that it can be clamped in any position by means of a screw clamp. The slide of the charger loading Lee-Enfield can also be clamped at any desired elevation in a similar manner.

Another form of sight is that used with the Austrian pattern, 1888, the Dutch, Italian, and Swiss rifles (see Fig. 9). This

Fig. 9.



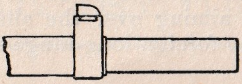
Backsight of Dutch Rifle.

type consists of a leaf, pivoted in front, between the high sides of the bed, it can be set at any graduation by means of a lever connected with the leaf; the sharp edge of this lever engages in notches on the high sides of the bed, and prevents the leaf

from moving. The end of the leaf is upturned at an angle of about 45°, and in it is cut the V. The advantages of this form are that the leaf is well protected by the sides of the bed; there is only one V and the sight scale is continuous from the shortest to the longest distance. If the rifle is let fall with the sight raised, the leaf can be knocked down without being bent. The backsight of the German rifle pattern, 1898, described on page 43 has the following advantages, it is very strong, it has only one V, the sight scale is continuous, the notches for the teeth of the slide are a good distance apart, and the spaces between them are equal, so it is as easy to adjust the sight at the short ranges as at the long.

The foresight blocks of most of the older rifles are brazed on to the barrel, while the back-sight bed is soldered and screwed on. The heating of the barrel necessary to effect this, particularly as regards the brazing, tends to bend the barrel slightly. The soldering also melts during rapid fire, leaving the backsight bed supported by the screws only, until the solder sets again, on the barrel cooling. To overcome these disadvantages, it has become customary to form the foresight block and the backsight bed with a ring or tube underneath, which fits round the barrel (see Fig. 10). This ring or tube is either soldered and screwed or pinned to the barrel, and forms a firm attachment for the sights.

Fig. 10.

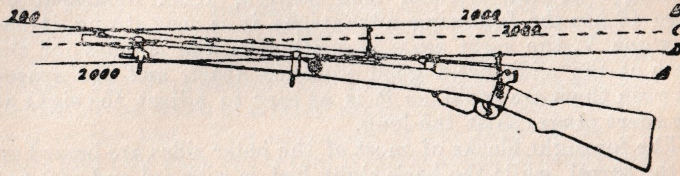


Foresight of Swiss Rifle.

The foresight is placed as near the muzzle as it conveniently can be, in order that the distance between the back and fore-sights should be as great as possible. This distance is termed the radius, and the advantage of a long radius is, that if, when aiming, the foresight is not quite truly centred in the V, the resulting error in direction or elevation is less with a long radius than with a short. The disadvantage of placing the backsight very far to the rear, in order to obtain a long sight radius, is that a great strain is thrown upon the lens of the eye in its efforts to focus rapidly the two sights and the object in turn upon the retina. The closer the backsight is to the eye, the greater is the required change of focus. When the backsight is too far to the rear, it appears indistinct and blurred while aiming, which more than neutralises the advantage of a long radius. Generally speaking, the older the firer is, the less accommodation of sight he has, *i.e.*, his eye can less easily rapidly change its focus; therefore he requires a backsight placed a good distance from the eye. The backsights of the Danish, Italian, and Japanese rifles are placed rather far back according to our ideas.

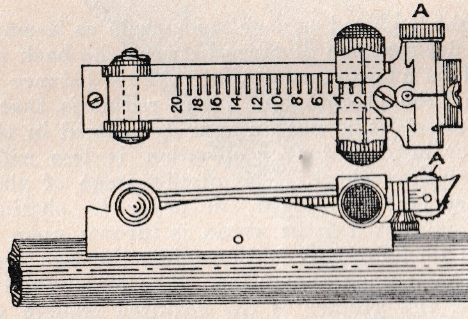
The Austrian pattern, 1888/90, Danish, and English rifles are provided with long range sights, the foresight being placed to one side of the barrel, and considerably lower than the ordinary central foresight. With the Austrian and Danish rifles aim

Fig. 11.



is taken through a V on the right side of the ordinary slide, while the foresight is placed on the side of one of the bands. The English long range sights consist of an aperture sight on the left of the rear end of the body, close to the firer's eye; when in use it remains at one fixed height. The foresight is carried on an adjustable arm, which can be set for distances from 1,600 to 2,800 yards. The advantage of long range sights is that the line of sight is lowered so as to obviate craning the neck or bringing the butt unduly low on the shoulder at the longer ranges. In Fig. 11 A represents the line of sight when aiming with the lowest sight, say that for 200 yards; B represents the same when aiming over the slide at 2,000 yards; C when using one of the foreign long-range sights at 2,000 yards;

Fig. 12.



Scale ½.

and D when using the English aperture sight at that range. The latter enables the eye to be kept at a convenient height, which remains about the same for any distance between 1,600 and 2,800 yards. In some foreign rifles, such as those of the

Mauser pattern, the stock has but little bend, in order to allow of aim being taken more comfortably at the longest ranges marked on the leaf.

Wind-gauge backsights have not been adopted yet by any of the great Powers, except by Great Britain and the United States.

Fig. 12 shows the type of sight employed with the short Lee-Enfield Marks I* and II Rifles.

The backsight, Fig. 12, is provided with one V at the rear end. Elevation is given by moving the slide along the stem of the leaf so that it travels up the curved ramps which are arranged so that the graduations are equally spaced. The slide is provided with a tooth on either side which engages in notches in the side of the stem. The teeth are released by grasping the ends of the slide with the finger and thumb. The bar carrying the V can be traversed to give wind allowance by means of the screw head A.

Fig. 13.

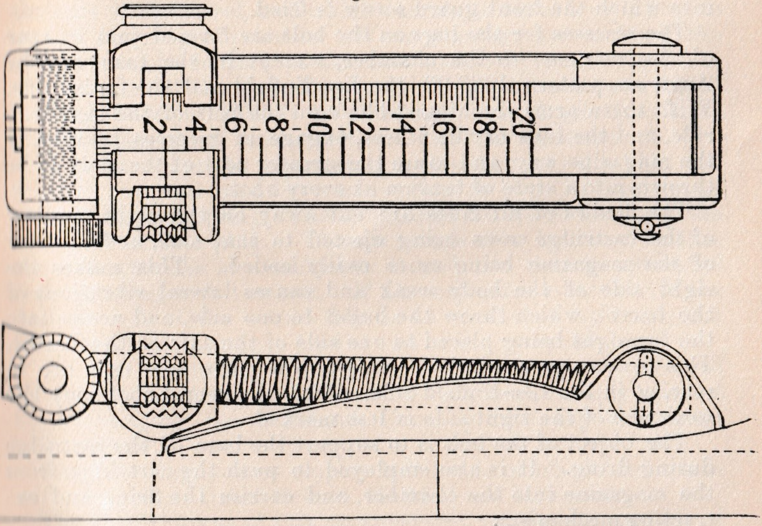


Fig. 13 shows the type of sight employed with the short Lee-Enfield Marks III and IV rifles, described on page 67.

Drift has not a great effect on the shooting of modern small bore rifles on account of their flat trajectories, except at long ranges beginning at about 2,000 yards; at extreme ranges the drift is very considerable. No attempt is made in military sights, except on those of the United States rifles, to give an automatic correction for drift, but with some of the old large bore rifles, such as the French Gras rifle, where the trajectory was more curved, the V's were placed slightly to one side, to give the correction for drift at the mean range at

which they were used, *e.g.*, the V used between 400 and 1,200 metres had the correction for drift required at 800 metres.

Telescopic sights.

Telescopic sights for rifles are being experimented with in the United States, but have not yet been adopted.

Body.

The body or shoe is the part of the rifle which screws on to the rear end of the barrel. It is bored out in line with the axis of the barrel for the bolt, which closes the breech end of the chamber. Under the body, beneath the rear part of the bolt the sear is attached. In rear of and below the breech end of the barrel is the opening by which the cartridges pass from the magazine to the chamber. In the Krag Jorgensen rifles this opening is on the left. In the Lee-Enfield and Lebel rifles which have the stock in two pieces, the rear end of the body has to be shaped so as to form a suitable bearing for the end of the butt, which receives the entire force of recoil. In the Lee-Enfield it takes the form of a socket into which the butt fits. Most of the other rifles such as the Dutch and Roumanian Mannlichers, the Japanese rifle, &c., transmit the recoil to the stock by means of a transverse projection underneath the body, into which the front guard screw is fixed.

The recesses for the lugs on the bolt are formed just in rear of the entrance to the chamber, except in the case of the Austrian pattern 1888/90, the Lee-Enfield and the Swiss rifle. With these arms the hinged block on the bolt of the Austrian rifle, and the lugs of the others, engage in recesses in rear of the magazine way, and cause the greater part of the body to be thrown into a state of tension at every shot.

The bodies of all rifles are cut away on the right to allow of the cartridge cases being ejected to that side, and to allow of the magazine being more easily loaded. This makes the right side of the body weak and causes lateral vibrations of the barrel, which throw the bullet to one side, and necessitate the foresight being placed to one side of the axis of the barrel. This is more particularly the case when the bolt lugs are in rear, as in the Lee-Enfield rifle. With the deep Lebel body the weakness of the right side is less marked.

Bolts.

The object of the bolt is to support the base of the cartridge during firing. It is also employed to push the cartridge from the magazine into the chamber, and carries the firing and extracting mechanism.

Bolts are divided into two groups, viz. :—

I. Those in which the bolt is rotated by raising the bolt lever before the bolt can be withdrawn.

II. "Straight-pull bolts" or those that can be drawn back by pulling the bolt lever straight to the rear.

Group 1, or rotating bolts, are used by all nations except Austria, Switzerland and Canada, which employ straight-pull bolts (see pages 35, 95 and 260). The advantage of a rotating bolt is that a very powerful primary extraction or loosening of the fired case in the chamber, can be obtained by means of cams on the body working against the bolt handle or lugs of

the bolt. If the bolt is supported by symmetrical lugs, as in the Swiss rifle and Austrian Pattern 1895 rifle, the lugs have to be rotated to clear their seatings, therefore complication is avoided by rotating the bolt directly by means of the bolt lever. On the other hand, the straight-pull bolts can be operated a trifle more quickly, and are more easily worked without removing the rifle from the shoulder; also the straight-pull bolt is less likely to be jammed by sand than a rotating bolt, for the latter draws the sand down between bolt and the left side of the body when it is opened, and occasionally causes a serious jam. A Lee-Enfield bolt cover is useful in guarding against this failure.

Of the rotating bolts the Lee-Enfield is the only one with the lugs near the rear part of the bolt. The disadvantage of this arrangement is that on firing the greater part of the body and bolt are thrown into a state of tension and compression respectively. This strain acting on the unsymmetrical central part of the body causes in a great measure the lateral vibrations, which necessitate the foresight being placed to one side of the axis of the barrel, and which exercise a disturbing influence on the accuracy of the rifle. When the lugs are in front, the symmetrical front part of the bolt and body resist the backward motion of the cartridge on firing, but the recess in which the lugs work is difficult to clean out if sand gets into it, as may happen in hot countries where dust storms occur.

In order to get the mainspring and striker into the bolt, the front or rear end must have an opening as large in diameter as that of the mainspring. These openings are closed either by the bolt-head or bolt plug. The advantage of a bolt-head is that the extractor can be attached to it and can thus be prevented from rotating with the bolt. If the extractor rotates with the bolt the end of the barrel has to be weakened by being cut away to afford clearance for the end of the extractor.

Another advantage is that if the end of the bolt be damaged by defective cartridges, the repair is then more cheaply effected by exchanging the bolt-head, than by renewing the entire bolt cylinder.

The following powers employ bolt-heads which do not rotate with the bolt:—Great Britain, Holland and Roumania.

The disadvantage of this arrangement is that on account of the bolt-head coming between the end of the barrel and the bolt, the locking lugs on the bolt are further removed from the barrel, and the body is lengthened unnecessarily; also, if the bolt-head becomes loose through wear, the shooting of the rifle is impaired.

The French and Russian rifles have bolt-heads which carry the locking lugs and rotate with the bolts. This system appears to have no advantages except for repair purposes over that in which there is no bolt-head, as it is desirable that the bolt, especially the front part, should be as solid and rigid as possible.

The following rifles have no bolt-head, the mainspring and

striker being introduced from the rear, viz., the Belgian, Danish, German, Italian, Japanese, Spanish, Turkish and United States rifles. The Danish rifle has only one locking lug, which engages in a recess below the entrance to the chamber. Such an unsymmetrical arrangement must give rise to considerable vibrations of the barrel in the vertical plane.

The front ends of the bolts of the Mauser rifles are distinguished by their simplicity and strength. In all these rifles except the Belgian and Italian rifles the extractor does not revolve with the bolt.

Of the three straight pull actions described in Chapter IV the Austrian pattern 1888/90 rifle is the least desirable, as the single hinged block on the bolt that resists the backward movement of the cartridge, is unsymmetrical, being situated beneath the bolt. The seating for the block is behind the magazine, therefore the greater part of the bolt and body have to support the backward pressure of the cartridge on firing. Also the body and bolt are inconveniently long. The Swiss rifle has similar disadvantages except that there is a locking lug on each side of the locking sleeve; therefore the bolt is symmetrically supported. The Austrian rifle, pattern 1895, is more conveniently arranged, the body is of the ordinary length, the locking lugs are symmetrical and are placed at the forward end of the bolt. Primary extraction with these two last rifles is obtained by cutting the locking lugs and their seatings on a screw pitch, whereby the bolt is slightly drawn to the rear as they are unlocked, also by means of the hammering action of the rod or cylinder, to which the bolt handle is attached, when the latter is smartly drawn to the rear.

Bolts work more smoothly backwards and forwards in the body, when they and the boltway in the body are a good fit, and well polished, also when the body encircles them well, and when they have a long bearing in the body when fully drawn back. The hardening of the bolt and body renders a very close fit difficult of attainment, as the hardening causes both components to warp slightly, therefore a small amount of play has to be allowed.

Double loading is said to occur, when, on pushing forward the bolt there are two cartridges ready to be introduced into the chamber at the same time. This occurs through excitement or carelessness on the firer's part as follows:—If the bolt is so constructed that the extractor does not at once engage the cartridge as it rises out of the magazine, and the bolt is drawn back before the cartridge is home in the chamber, then when it is pushed forward again another cartridge is pushed out of the magazine while the first one remains partly in the chamber and a jam results.

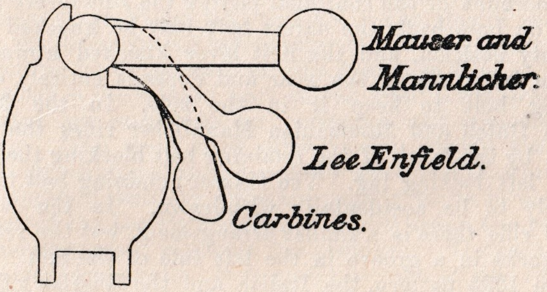
To enable the extractor at once to engage the cartridge as it rises up out of the magazine, the head of the cartridge should be free to rise up the face of the bolt or bolt head so that the rim at once passes under the claw of the extractor. For this

reason bolts and bolt heads that are recessed on the face have the lower part of the rim of the recess cut away. The French and Russian bolt heads are exceptions to this rule, as their magazines are so arranged that another cartridge cannot be fed up from the magazine until the bolt has been fully closed and the bolt handle turned down, in which case the extractor is sure to have sprung over the rim of the cartridge. Another form of double loading occurs when the bolt is not fully drawn back after firing, the empty case is then not ejected, but on pushing forward the bolt the top cartridge in the magazine will be fed forward.

An interrupter is used in the magazine of the Russian rifle, to prevent the possibility of double loading occurring, through the extractor not at once engaging the cartridge.

In Continental rifles, such as the Mauser, Mannlicher, Lebel and 3-line rifles, the bolt lever projects at right angles from the bolt in a horizontal direction. In the Lee-Enfield (see Fig. 14) it projects downwards; in this case the knob has not

Fig. 14.



to be raised so far as to be turned vertically above the bolt; but when the bolt lever is horizontal and rather long as in the Mauser and Mannlicher rifles, it comes very easily to the hand, without the eyes being taken off the object. Several of the carbines, such as the French pattern 1890, and the the Roumanian carbines, have the bolt lever turned down (see Fig. 14), so that it may lie close to the stock, to allow of the weapons being easily inserted into the leather bucket carried on the saddle. This pattern is not easily operated when the attention is fixed on the object. In reloading, the right hand has to travel from the small of the butt to the bolt lever, therefore the nearer the bolt lever is to the small of the butt, the more quickly it is gripped by the right hand. Fig. 15 gives the relative position of Lee-Enfield and Lebel bolts; A A^1 shows the position of the knob of the Lee-Enfield rifle, when raised and lowered, while B B^1 represents that of the Lebel.

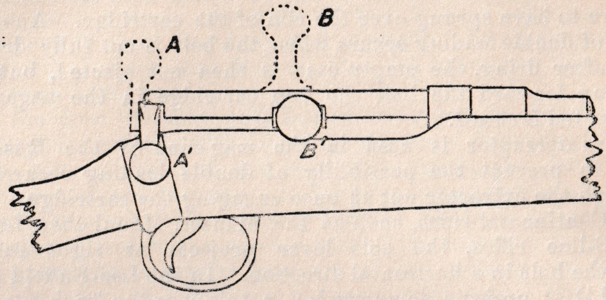
When the bolt lever turns down in front of the shoulder in the body, as it does in the Lebel and Mannlicher rifles, it

would act as an extra resistance in the improbable contingency of the two locking lugs being carried away.

Retaining bolt.

It is important that an efficient arrangement should be provided for stopping the backward travel of the bolt, to prevent

Fig. 15.



the latter being accidentally lost; this is especially needed when the rifle is carried muzzle upwards by mounted men, for on account of the continual jarring the rifle receives when carried on horseback, the safety bolt may be knocked out of the safety position, and the bolt lever knocked upwards, so that the bolt falls to the rear and depends entirely on the retaining bolt to keep it in the rifle. In the Mauser, and the Dutch and Roumanian Mannlicher rifles the bolt is stopped by the tooth of the retaining bolt blocking the groove for the left locking lug. The Mauser retaining bolt is not at all likely to be accidentally withdrawn. In the Austrian 1888/90 rifle there is a similar arrangement, but the retaining tooth works in a groove in the left side of the bolt. In the Austrian 1895 pattern, the Italian and the Russian rifles, the retaining tooth is operated by means of the trigger, which is well protected from accidental blows by the trigger guard. With the Lee-Enfield rifle the bolt is stopped by the bolt-head striking the resistance shoulder, but it is possible that by a blow the bolt-head may be rotated free from the retaining spring, in which case the bolt will fall out of the rifle. The bolts in the Krag Jorgensen rifles are also stopped by the locking lug meeting the resistance shoulder, but before the bolt can come out the extractor spring must be lifted clear of the body and the bolt rotated to the left.

Magazines.

The value of a magazine rifle largely depends upon its magazine and the value of the magazine upon the method of charging it. The merits and defects of the various methods of charging magazines are discussed in Chapter III. The cartridges in a magazine loaded by a clip are raised by a lever pivoted at the front bottom corner of the magazine and operated by a flat spring. The lever must be narrow enough to pass freely between the sides of the clip; the free end is either slightly rounded, as in the Dutch Mannlicher, or it

carries another small lever, operated by a flat spring, as in the Austrian and Roumanian rifles. In the latter form the front ends of the cartridge are better supported. Similar levers are used in the magazines of the Belgian and Russian rifles. In the short Lee-Enfield rifles, in the German, Spanish and Turkish Mausers the sliding platform is raised by a spring of ribbon steel of a zig-zag form. In the Japanese and Swiss rifles the sliding platform is raised by a wire spring, arranged in a zig-zag shaped coil. The sliding platforms of the above rifles have one side higher than the other, so that the cartridges in the two columns may be presented alternately at the opening from the magazine into the boltway. In the Spanish, Turkish and Japanese rifles the soldier's attention is drawn to the fact that his magazine is empty by the face of the bolt being stopped by the end of the platform, on his attempting to close the bolt after extracting the last cartridge. This may occasionally prove useful in the heat of action, but is inconvenient when closing the breech with the magazine empty at drill.

The advantages and defects of the Krag Jorgensen magazine are detailed in Chapter III. This type of magazine cannot be so rapidly loaded as those adapted for use with the chargers or clips shown in Plates LXI to LXV. The plan of compressing the magazine spring before inserting the cartridge is also employed in the Canadian Ross rifle (see page 28).

The stock is the wooden part of the rifle in which the body and barrel are embedded for protection and convenience of handling. The wood most often used is Italian walnut; it must be thoroughly seasoned and dry when manufactured. Stocks.

The stocks of military rifles are usually made in one piece, but those of the Lee-Enfield and the Lebel are in two pieces.

The advantages of stocks in one piece are: The butt cannot become loose and shaky; it is easier to take off the rifle; the body of the rifle can be made smaller, as it is not necessary to provide a socket or bearing for the butt to bear against (see the difference between the Lee-Enfield and Mauser or Mannlicher bodies); the body, stock and trigger guard can be securely joined together by two screws; and lastly no stock bolt is required.

When the fore-end and butt are two separate pieces, if either part becomes unserviceable it can be replaced separately; this is an economy both during manufacture and after the stock gets into the service. The small of the butt is strengthened by the steel stock bolt which passes through it.

The fore-end is attached to the barrel by means of two bands which pass round the fore-end and the barrel, or round the fore-end and the handguard, enclosing the barrel between them as in the Swiss rifle. The lower band passes round a little in front of the backsight bed, and the upper band at the extreme end of the fore-end. The front end of the fore-end is usually protected by a sheet steel cap called a nose-cap. The upper band generally carries the bar on to which the

pommel of the sword bayonet fits. In the German Mauser and short L.-E. rifles this bar is on the nose-cap, the sword bayonet does not touch the barrel, and so fixing bayonets has less influence on the elevation of the rifle than when it is attached to the barrel.

In the Swiss rifle the fore-end and handguard do not touch the barrel in front of the backsight bed. A tube, called the barrel sleeve, is gripped between the front end of the fore-end and handguard, and the barrel passes through it; the hole in the sleeve is just large enough to ensure that the barrel does not jam in it. This method of manufacture prevents the wood of the barrel groove, between the two sights or the bands, from exercising any varying influence on the vibrations of the barrel.

With the short Lee-Enfield rifle a different method of stocking is introduced to effect the same objects (see page 69).

Handguards.

Handguards consist of thin wooden covers, which fit over the barrels of magazine rifles to prevent the hands being burned by the barrels after rapid fire. They are very necessary with magazine rifles unprovided with a barrel casing, on account of the rapidity with which such rifles can be fired, and the great heat generated by smokeless powder. The rain is liable to get under them and cause the barrel to rust externally; for this reason it is advisable that they should be easily removable, so that the barrel may be wiped dry when necessary. The Lebel, Belgian and Danish rifles have no handguards, and the Austrian 1888/90 rifle was only provided with a canvas and felt one after it was first introduced. This is an unsatisfactory material to use, on account of its holding moisture and its liability to become charred and spoiled by very rapid firing. The handguard for the Lee-Enfield rifle has riveted to it two curved springs of this form Ω, which grip the barrel and hold the handguard on. The Dutch and Roumanian handguards are fixed on in a similar manner. The handguards of other military rifles generally fit under a projection on the backsight bed and under the lower band or both bands.

In the short Lee-Enfield rifle the handguard is in two parts and extends from the body to the nose-cap. The rear part is secured by two curved springs riveted to it, which grip the barrel in rear of the backsight, the front part is gripped by a jointed band in front of the backsight, and the front end is held down by the nose-cap. It does not touch the barrel, except where the springs grip the latter.

Butt.

The butt should bend downwards below the axis of the barrel produced, so that when the rifle is thrown up to the shoulder the head has not to be bent down inconveniently to align the sights for the shortest range. When the butt is rather straight it is more convenient for aiming at extreme ranges; for this reason the Mauser butts are rather straight, as no long range sights are provided. With a straight butt, however, there is more liability of firing over the object when snap shooting.

The butts should fit the men in order that the best results may be obtained when snap-shooting. The average length used in the English service is $13\frac{1}{4}$ inches from butt plate to trigger, a proportion $\frac{1}{2}$-inch longer and $\frac{1}{2}$-inch shorter than this are also issued. The Italian carbine has a very short butt for convenience of carrying; it measures only $12\frac{3}{8}$ inches from trigger to butt plate. The Swiss rifle, in order to suit their method of deliberate fire standing, measures only $12\frac{1}{2}$ inches between the same points.

For snap shooting a light rifle is necessary, therefore it is advisable, if possible, to carry the cleaning implements, such as the cleaning rod or pull-through in the soldiers kit or on his person rather than on the rifle itself. The short Springfield rifle is provided with a butt trap, containing a metal oil-bottle, holding oil at one end and a pull-through at the other. We are the only other nation that carry the pull-through and oil bottle on the rifle. Other nations carry a cleaning rod with the exception of the United States, Austrians, French, and Swiss, who carry no cleaning rods on their rifles, although the Austrians carry one in three pieces in their kit. The cleaning rods are either full length or half length; the former will clean the entire bore by using the rod from the breech and muzzle, but two of the latter must be screwed together before use.

CHAPTER VI.

Outlines of Manufacture and Inspection of the Service Rifle.

Specification and Drawing.

The design of the rifle having been decided upon, a specification and drawings are prepared to govern the manufacture and inspection.

Whilst the object of the manufacturer is to make a serviceable weapon, well up to the specification, he has always to do so at as low a cost as possible. For this reason an independent inspection is given to the rifle, and the points that are constantly before the department charged with this duty are:—

(1) Accuracy in shooting.
(2) Safety and wearing qualities.
(3) Interchangeability of components.

Material.

The specification gives particulars as to the material to be employed for each separate component. These materials are steel, iron, wood, and brass.

Steel.

Steel, the most important of the materials with which we are concerned, is a variety of iron containing carbon to the extent of from 0·05 to 1·5 per cent. Other substances are also present in varying proportions, but the carbon is the most important ingredient, and it is to the presence of the carbon that steel owes its most valuable property, viz., that by certain heat treatments and methods of cooling it can be brought to any desired state of hardness or softness. Steel may be classified as "mild" or "high carbon," according as the amount of contained carbon is below or above about 0·3 per cent. As the property of "hardening" increases, up to a certain point, with the percentage of contained carbon, a "high carbon" steel is employed for such important components as the bolt, cocking-piece, and sear, which have to resist considerable pressures, or have wearing surfaces. When the component is required for work of a springy nature, such as the cut-off, retaining spring for bolthead, or sear spring, a special quality "high carbon" steel is employed, as this quality of spring cannot be imparted to a mild steel. For the barrel either "high carbon" or "mild" steel may be used, but, in any case, the steel is of a high quality, and greater strength is required of it in its

mechanical tests than would ordinarily be the case with mild steel. The manufacturing processes, the difficulties of boring and drilling an accurate "tube," have to be kept in view at the same time as the qualities that will give safety to the barrel under firing pressures.

For the minor components, such as trigger-guard, nose-cap, screws, &c., a lower grade of mild steel is employed, which, though of ample strength, is cheaper and easier to work.

The terms "cast" and "forged steel" are apt to be rather confusing. All steel is originally cast into an ingot, and by "forged steel" is meant that which has subsequently been subjected to forging. A forging is more expensive than a casting as involving more time and labour, but the tensile strength and soundness are increased by the work so put in. "Cast steel" may apply to any steel that has not been forged, but in the trade this term has come to be identified with steel made, by a special process, in small quantities in crucibles. As this particular process is mainly applied to "high carbon" steels of good quality, it may generally be taken that this is the class of steel referred to when "cast steel" is mentioned.

Where toughness is the desired quality, as in the bolt-head and stock-bolt, a special "gun-iron" is employed. This contains less carbon than the mildest of steel, in fact, approaches wrought iron in its composition.

For any particular component the following points have to be borne in mind in deciding which is the most suitable class of steel to use:—

(A) The function of the component in the finished rifle.

(B) The work to be performed on it in the manufacturing processes, and, conjointly with this, the cost of material and wear of tools.

The iron and steel are obtained in various forms, depending on the subsequent operations. Thus, for example, the bodies are made from long rectangular bars, the trigger from bars whose cross section resembles the finished component, barrels are supplied in "moulds" or round bars about one foot long, the magazine cases are stamped out of sheets which are afterwards folded and brazed, the smaller pins are made from steel wire, as is also the main spring, whilst the springs for the rear handguard and magazine platform are made from "ribbon" spring steel.

An Inspector may take a sample of material at any time, and subject it to chemical analysis and mechanical tests.

Manufacture.

The principal manufacturing processes are forging and machining, the former being employed as a preliminary to the latter in those cases where the form of the raw material necessitates it.

Drop forging is generally employed. One end of the bar is heated to a cherry red, and brought roughly to shape between two dies specially prepared for each component, one being held in the anvil and the other in the steam hammer, which is allowed to drop on it. The finished forging may be arrived at by one or by a succession of operations, each bringing it nearer to the desired form. Whilst hot, it is cut off the bar. These are the first steps in the formation of such components as the body and bolt, and their object is to save the immense amount of cutting which would be required were the article to be cut out of the solid.

The preliminary stages in the manufacture of the barrel are either forging or rolling, or both. The object here is to elongate the mould to the approximate length of the finished barrel, and also to shape the exterior.

The rolling mill is of somewhat peculiar construction, ten pairs of rolls being arranged alternately vertically and horizontally, and in close proximity to one another; each pair of rolls is of different diameter and figure, depending on the work already done by the preceding pairs, and so arranged that the elongation is practically continuous.

If the elongation is to be obtained by forging, a "Ryder hammer" is employed, the heated moulds being held in tongs and passed by hand between pairs of semi-circular dies (graduated in size), the upper of which is rapidly moved up and down by means of eccentrics or cranks on a power-driven shaft.

Whether forged or rolled, the barrel is afterwards re-heated at the breech end, and the "Knox form" obtained by drop-forging.

The forging or rolling, besides its primary object, has the effect of improving the homogeneity and structure of the steel.

Annealing and Pickling.

In order to facilitate the work of cutting the component to the desired shape, it is usual, when possible, to reduce the hardness of the material, temporarily. This is effected by annealing. The finished forgings, for example for the body or the bolt, are placed in an iron box filled with vegetable charcoal, and heated in a muffle for several hours, after which the furnace is allowed to completely cool down. During this process the interior is softened, but a hard scale forms on the surface, and this is removed by "pickling," *i.e.*, the forgings are immersed for a short time in a solution of sulphuric acid and water. This dissolves the hard scale, and the component is then ready for machining.

Machining.

This is a general term, and comprises all the various operations which are wholly or partially mechanically performed, and have for their object the reduction of the components to

their correct size and shape. In practically every case this is effected by cutting, but there are several methods of applying the cutting tool, and the differences between them are indicated in the names of the different operations. The more important of these are turning, drilling, boring, slotting, milling, and shaping.

Drilling consists in cutting a hole by means of a drill, the *end* of which is shaped to form the cutting edge or edges.

Boring consists in enlarging a circular hole by means of a boring bar, the *sides* of which form cutting edges, or from the sides of which separate cutters project.

In milling, a hardened steel wheel with a series of cutting edges on its rim, or on one or both of its sides, is revolved, and the work is automatically fed forward or rotated as the cutting progresses.

In shaping, the work is held stationary whilst the cut is being effected by the tool. This is given a reciprocating motion, but cuts only during the forward stroke.

Slotting is somewhat similar to shaping, but the tool is given a vertical motion, and the process is used for enlarging a circular hole (already drilled) in any required direction by traversing the work.

It is obvious that there must be a relative motion between the tool and the work, and, further, that one or both of them must be moved to give the requisite feed to bring or keep the tool in contact with a fresh surface or portion of the work. Much ingenuity has been expended on the design of machines to perform these motions automatically or semi-automatically, enabling large numbers of components to be made with a minimum of labour. It should be understood that the "cut," or amount removed, is necessarily small, and that, therefore, a large number of varied operations have to be performed on each component before it is brought to the correct size and dimensions. It is one of the chief objects of the factory staff to so arrange the sequence and number of these distinct operations as to keep down expenses to a minimum.

It is not to be supposed that a machine once adjusted to perform a certain operation is capable of repeating the same indefinitely, and reproducing in large numbers components in any particular stage, all absolutely identical. The wear of the cutters and fixings proceeds slowly but surely, and it becomes necessary to fix manufacturing limits within which the serviceability of the article is not appreciably affected. These limits, which are generally within a few thousandths of an inch, vary with the importance of the component and the stage at which it has arrived, and it will be understood that in some instances no toleration (within the powers of measuring) is permissible.

Gauging.

These considerations bring us to the necessity of gauging. This commences in the machine room, where the machine

hands are provided with gauges by which they can check the work being produced, and bring to notice the necessity for re-adjustments of the machine, or for tool-sharpening. Such work is performed by qualified fitters, and the gauges by which they are guided are of a higher order of perfection than those used by the machine hands. The machined components are viewed and gauged again by an independent staff.

In designing a gauge for a component it is most important to consider with what other components it interworks or comes in contact, and what parts of each must have a definite size to ensure ease of assembly and interchangeability. Following from this it will frequently be found that a gauge, or a portion of it, resembles one or more of the components adjacent to that, shape and dimensions of which it is designed to check. The making of gauges calls for exceptional skill, and their high price is commensurate with the degree of accuracy required. A special set of gauges, known as standards or reference gauges, are kept by the Inspection Department, and used with the greatest reservation for the sole purpose of checking the working gauges, and preventing the latter being used when wear or other causes have rendered them unreliable. Thus it may be seen that the whole question of gauging forms an intimate link between the factory and inspection staffs.

Barrel.

As the barrel is the most important component in the rifle, and as some of the operations in the making of it are peculiar to it, they are worthy of more detailed investigation. The barrel is subjected to inspection in various stages, and the specification requirements at each stage serve as convenient points from which to review the methods employed to arrive thereat. Starting then with the forged or rolled barrel, it is first inspected in the "fine bored stage." It is viewed, and must take a plug ·3025-inch in diameter; the exterior must be concentric with the bore, and must be generally of correct dimensions. The bore must be straight. Briefly, the processes the barrel has undergone are rough turning of the exterior, drilling, finished turning, polishing, and boring. As has already been indicated, it is the ever-present concern of the manufacturer to arrive at the desired end with the minimum of expense, and hence it by no means follows that the procedure in different factories as regards the sequence and number of operations are identical. Thus, for instance, the drilling may be started from both ends simultaneously, and be carried out in several distinct operations, or it may proceed from one end to the other without any break, and be completed in one operation. The drilling bits and boring bars slide horizontally along the bed of the machine whilst the barrel revolves. They are bored with a fine hole longitudinally, through which a cooling lubricant is pumped, and this washes out the "swarf" or cuttings from the bore. The important considerations are

that the bore must be straight and concentric with the exterior; it is the business of the factory, knowing how far they can trust their own methods and machines, to take steps, such as intermediate viewing and setting, as shall ensure this. The test for straightness depends upon the light and shade effects which may be seen upon the bright surface of the smooth bore. A line of shadow is thrown down from the muzzle to the breech, and this line must remain straight while the barrel is slowly revolved. Any bend or curvature in the line of shadow indicates a corresponding want of straightness at that point in the bore. A more modern test depends on the multiple reflections of the muzzle, which appear in a smooth straight bore as concentric rings. By suitable regulation of the amount of light which is permitted to strike the muzzle, this can be made an exceedingly delicate test, and the slightest want of concentricity is an indication that some correction is needed. This is obtained by setting. Barrel-setting was formerly looked upon as the work of a highly-skilled specialist, but, owing to improved mechanical methods, the degree of skill required is now considerably diminished. Having located the error, the older method (which is still largely in use) was to strike the barrel a transverse blow with a copper or brass hammer in the required direction, estimating the required strength of the blow. But, in conjunction with the system of testing by concentricity of rings, means are provided whereby the barrel can be mechanically bent to the necessary extent to overcome the former want of straightness. To test the concentricity of the bore and the exterior, the barrel is spun upon plugs entering the bore.

The barrel is next inspected in the "rifled stage." It is viewed, and must be free from greys and scratches; the depth and the pitch of the rifling are tested. The important feature of the rifling machine is the method of regulating the cut; this may be taken approximately as one-thousandth of an inch, thus it is clear that the rifling of each groove requires, say, five to seven cuts to be made upon it. The cutter box (Fig. 16) is drawn through the barrel by means of the rod, A, the tooth, B, of the cutter taking out a shaving in its passage. The cut is regulated by the rod, C, for when this is screwed outwards, the spring, D, in the cutter box bears on the cutter, and the slope, E, on the cutter rides up the slope in the cutter box, and consequently the cutting tooth, B, protrudes to a greater extent. The rod, A, is revolved mechanically to give the necessary pitch to the rifling.

In the next stage the point of importance is to see that in forming the screw, which afterwards enters the body, the relative positions of the thread and the flat on the Knox form are preserved, so that the subsequent breeching up is correct.

In the "first chambered" stage the cartridge chamber has been bored to within ·002 inch of the finished size, the extractor way has been cut, and minor machining operations, preliminary

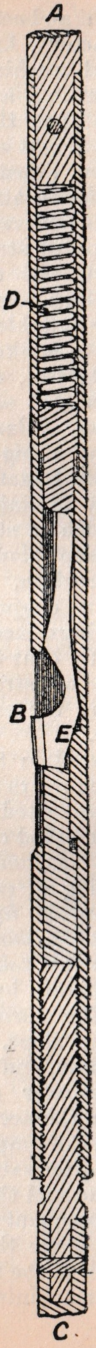


Fig. 16.

to the fitting of the sights, have been performed. When next submitted for inspection the assembled sight bed and the block band foresight have been fitted, and the dimensions, fitting, and positioning of these are tested.

Proof.

At this stage the particular barrel, body, and bolt, which will afterwards form part of the same rifle, are first brought together, and, being numbered, the action is completed with "slave components" which are kept for this purpose, the back sight is stripped, and the barrel proved. This is carried out with a proof cartridge, giving a pressure considerably above that to which the rifle is ordinarily subjected, and it is fired under conditions ensuring safety to the firer in the event of any portion failing to stand the test. The high pressure has the effect of setting up the chamber and the recoil shoulders of the bolt and body. It is to allow for the consequent enlargement that the first chambering is left two-thousandths of an inch small.

Incidentally it may be noted that at this firing proof an intimate relationship is established between the recoil shoulders of the bolt and body, and the fact that this affects the shooting of the weapon is the reason for taking pains to ensure that rifles always have their own bolt.

After proof the barrel, body, bolt, and bolt head are examined to see that they are sound, and they are then marked with the proof mark (Fig. 17).

Fig. 17. 

The barrel next comes forward in the "browned and finished chambered" stage. Browning will be considered together with the other finishing operations. Since the proof the chamber has been brought to finished dimensions, and it is now gauged. In addition the bore is spun, for straightness, on a rod of which only two small portions bear, namely, at the breech end and the centre of the bore; any want of straightness is thus made apparent by a lateral movement of the muzzle end. In addition the bore must be parallel from end to end, and take a ·303 or ·304 plug and reject a ·305 plug. The barrel and body (which has been browned) are then assembled, and submitted in the "breeched up" stage; the relative positions of the flat on the barrel and the body are tested, and the barrel and body, supported on a plug in the muzzle and another in the boltway of the body, are spun to ensure their axes being in alignment. Finally, the sights are completely assembled, and the barrel is placed in a sight-testing machine, which enables the height of the leaf above the axis of

the barrel to be checked. This is done for 200, 500, 1,000, an 1,500 yards' elevation, and intermediate heights are checked by a profile gauge, which is applied to the ramps and checks their figure. The general working and fit of the slide and wind-gauge are also tested.

There is one other operation which is peculiar to barrel work, namely, "lapping." This is effected by placing a stopping of tow and a rod with a jagged end a few inches inside the muzzle, and pouring in molten lead. This sets in the grooves of the rifling and adheres to the rod, by means of which it can be worked up and down the bore, the rod being given a twist so as to follow the rifling. By the addition of a paste of oil and emery powder, which is carried by the lead plug, any small imperfections which may be present can be removed. This process must be used with discrimination, as it is clear that unlimited lapping will enlarge the bore considerably.

This completes the manufacture and inspection of the barrel as a separate component.

Finishing Operations.

This term includes operations such as polishing and bobbing, which serve to give a finish to machining operations; the treatment of steel to give it certain qualities; and also the preparation of the surface to avoid rusting, and to give it a dull appearance.

Polishing is principally used for the barrel, and is effected in this case by rapidly moving the barrel between spring clams faced with emery and oil. Bobbing consists of fine-grinding and polishing with rapidly-revolving emery wheels; the work, if cylindrical, is revolved also, and is traversed to and fro in front of the bob.

The treatment of the steel has in general two objects, namely, to harden it or to give it elasticity. Hardening may be used:—

(1) To restore the tensile strength to a cast steel that has been softened for machining purposes.

(2) To give a hard surface to resist wear in cases where moving parts come in contact.

(3) As a preliminary operation to tempering in spring-making.

Hardening is invariably effected by heating the component (generally to about 740° C.—a red heat) and then cooling it more or less suddenly, or, as it is termed, "quenching" it, in water or oil. This, however, leaves the steel so brittle that small components can be snapped between the fingers, and, therefore, for whichever of the above reasons hardening has been used, it is generally modified by subsequent tempering. This consists in again raising the temperature of the steel so as to partially soften it, and then allowing it to cool, or quenching it. The amount of temper to be given is governed

by the purpose the component is to serve, and is regulated by the temperature to which it is raised, and the rate of cooling. In tempering springs, the temperature employed is about 290° C. A bath of nitre or lead is sometimes employed as a tempering medium.

Case hardening is used to give a hard surface, where required, to those components made of iron or mild steel, which do not contain sufficient carbon to enable them to be hardened as has already been described. In these cases the parts are packed up in an iron box with bone-dust or shreads of leather (which forms the source of supply of the carbon necessary to effect the process), the lid of the box is sealed with fireclay, and the whole subjected to a lengthy heating at a considerable temperature. They are then quenched in oil or water.

The processes used for protecting the surface or for giving it a dull appearance are oil blacking, browning, and blueing.

Oil blacking is effected by heating the component, and then dipping it in oil and allowing the oil to drain off; this leaves a black carbonaceous deposit on the surface. A similar process is blazing off, which derives its name from the fact that the oil is ignited by the heat of the component. These methods are almost a part of hardening and tempering, to which they frequently form the sequel, the heating required for the former processes serving also for the latter, whilst the dipping in oil in the latter serves the double purpose of quenching the part and blacking it. Oil blacking and blazing off can, however, be carried out with mild steel, and these processes are used for nearly all the smaller components.

Browning may similarly follow the hardening or tempering processes, or it may be applied direct. It is a chemical process, by which the surface of the steel is given a dull, dark appearance by oxidation produced by acids used in the mixture.

Blueing is limited to a few components, chiefly to be found on the dial and back sights. It is effected by oxidation of the surface by heat. The part to be treated is heated in charcoal, or in a bath of nitre and manganese dioxide.

Stocks.

Walnut is the wood most commonly used for stocks; the wood is received from contractors roughly cut to form, and, after examination, it is carefully stored to season for about three years.

Amongst the machining operations the turning of the butt and fore-end on Blanchard lathes is particularly interesting; in this machine the wood and an iron dummy shaped to represent the butt or fore-end, as the case may be, revolve side by side at the same rate. A wheel is kept in contact with the dummy, and by the protrusions or recesses thereon is moved away from or allowed to approach the axis of rotation. The cutters are carried on the rim of a similar wheel, which is

rapidly revolved, and both this and the guiding wheel being supported in the same frame (which travels laterally) the cutters are constrained to follow the movements of the guiding wheel, and thus give to the wood a shape similar to that of the dummy.

A similar arrangement is used for glass-papering the parts after the finished turning, but in this case the cutters are replaced by layers of felt and glass-paper glued on to the rim of the wheel. The finished butt and fore-end are both soaked in linseed oil for half-an-hour. The inspection of these components is left to the finished stage, when, in addition to the usual points, the quality and condition of the wood are looked to.

Finished View.

The assembly of the components to form the finished rifle calls for no special remarks.

The points of importance in the final inspection of the rifle are :—

(1) To see that all components are complete, and are marked with a view mark, and number and proof mark where applicable.

(2) To see that the various parts fit and bear correctly, and in this connection the fit of barrel, fore-end, and nose-cap, or "stocking up," is of special moment; the object is to control the vibrations of the barrel on firing, and to secure a common basis from which the sighting of the rifle has been carried out. Any difference in this particular must affect the accuracy of the weapon, and is therefore carefully looked to.

(3) The working of the action is examined, and the magazine, charger guide, and extraction tested with the aid of dummy cartridges and fired cases.

(4) The weight of the pull-off and certain springs are tested.

(5) The general finish is examined, the aperture and dial-sights are tested, and the working of the slide and wind-gauge of the back-sight looked to.

If satisfactory, the rifle receives the finished view mark, and is then sent to the range for testing.

Testing.

All rifles are fired at 100 feet, and 10 per cent. are also fired at 600 yards, any which give doubtful results at the shorter range being included among those tested at the longer. In both cases the rifle is held in a mechanical rest, designed to approximate to the conditions under which it is ordinarily fired as regards points of support, recoil, &c. Means are provided for laying the rifle by hand-wheels, and with the aid of a special telescope laid on the blade of the fore-sight and bearing on the upper surface of the wind-gauge, a true, full regulation sight is obtained. After laying, and before firing, the telescope is carefully removed.

The following is the procedure in the firing test at 100 feet range—

Trial shots are first fired, and, if necessary, the fore-sight blade is adjusted laterally (within limits), or it may be replaced by a lower or a higher one as required. Five rounds are then fired, and four shots out of the five must come within a rectangle 1 inch broad and $1\frac{1}{2}$ inches high. Failing this, the rifle is not accepted.

At 600 yards nine out of a group of ten shots fired must lie within a two-foot circle.

After passing a satisfactory test the blade of the fore-sight is fixed by the top edge of the front of the stool of the block band fore-sight being punched into a recess cut in the fore-sight.

The rifles are once more given a general inspection, and are then packed and passed into store.

CHAPTER VII.

Notes on the Shooting of Rifles.

It is only within the last 50 years that the movement of the rifle on firing, and its effect upon the line of projection of the bullet, have been at all well understood. It was a great puzzle to those who first observed it, to find that sights carefully adjusted to the axis of the barrel did not coincide with the line of departure of the projectile. The explanation soon offered itself; that the want of symmetry of the mass of the stock, action, and barrel led to its displacement under the blow of the explosion of the charge, and that, while some bending of the barrel took place, there was a tendency of the whole weapon to move round the centre of gravity situated below the axis of the barrel; and that these effects began to be exhibited before the travel of the projectile to the muzzle was completed.

It seems to have been the phenomenon of the movement of the barrel affecting the flight of the bullet which gave rise to the persistent belief of early artillerists that the first part of the flight of a projectile was in a line absolutely or practically straight; and, apparently in its turn, this belief gave rise to the theory of a "point blank" range. It was found that, when the bore had been carefully aligned on a mark, the projectile did not strike below it, even when fired from some little distance. On the assumption that the barrel did not move, it seemed evident that the shot could not be falling during the first part of its flight. There is no greater mistake, however, than to look upon a rifle as a rigid body incapable of bending. The barrel of a rifle is very sensitive to strains. Such a pressure as can be put on it by the finger will bend it perceptibly, so will the heat of a flame applied to one side of it. The barrel may be absolutely tight in the action, yet it has behind it the butt, which is very capable of bending under pressure. The wooden fore-end, necessary to take the strain of the bayonet, is liable to put pressure on the barrel at one or more points, and may even keep it in a condition of tension. The bands holding the barrel to the stock have a similar effect if they bear tightly on the former. Supposing that the screw by which the barrel is screwed into the action be not perfectly true, the barrel will not have equal support all round, and it will be subjected to unsymmetrical strains when fired. Similarly, if the lugs on each side of the bolt (which fit against shoulders cut for them in the action, and so take the force due to

pressure of the powder gases) be not perfectly symmetrical, so as to take their bearing simultaneously on firing, the small lateral movement which then takes place before they are both sharing the work, will be enough to give a lateral movement to the barrel, and will affect the direction of the flight of the bullet very noticeably, throwing it some minutes to one side or other of the prolongation of the central line of the barrel when at rest. The use of a bolt belonging to another rifle may in this way affect the accuracy of the sighting. In fact, it may be said that anything which interferes with the normal vibrations of the barrel will adversely affect the accuracy of the rifle, or will modify the sighting required. A rifle clamped in a rest will not shoot to the same sighting as it will when held in the hands, and the effect of resting it near the muzzle, or upon the trigger guard (for instance), will be, as a rule, to vary the sighting.

Variations in the vibration may arise from other causes besides those already mentioned. During the passage of the projectile along the barrel, the gases pressing upon its base are giving it a constantly accelerated motion, and are at the same time exerting pressure in all directions upon the bore and the base as well as the sides of the chamber. In fact, the whole bore in rear of the bullet during its passage is expanded to a minute degree. The bullet, when it has once passed from the chamber into the rifling, fits tightly, and, so far as possible, seals the bore, meeting a frictional resistance during its passage. Any variation from one shot to another in the amount of this friction will affect not only the velocity of the bullet, but also the degree of movement which has been imparted to the rifle before the bullet has reached the muzzle, and, therefore, the direction in which the bullet is discharged, which forms the basis or zero of the sighting scale. Similarly, an increase or decrease in the weight or composition of the projectile, or in the amount or rate of ignition of the explosive, will affect the " zero " of the sighting scale more or less perceptibly. It does not necessarily follow, for instance, that because at short or moderate distances, the bullet strikes higher with one charge than with another, the velocity is actually greater or the trajectory flatter. The effect may be due to the bullet starting on its flight at a higher angle; see experiment on page 215. The rifle must, in fact, be looked upon as being itself in a state of motion before the projectile has left it. Its movements on firing are described in Chapter III, Part II.

The actual and relative effect of these influences will, of course, vary largely under different conditions. A heavy barrel is less affected than a light one by equal strains. A heavy charge will set up in the same barrel more vibratory and general motion than a light one. When the velocity is low, on the other hand, the motion will have more time to develop itself before the projectile emerges, and consequently,

though it is less violent and rapid, the whole disturbance may be equally great.

The general effect upon the sighting of the movement of the arm, may be to throw the bullet either above or below the line in which the axis of the barrel was directed at the moment before the ignition of the charge; the former effect has been called positive and the latter negative jump. The direction of the jump in any type of arm may usually be seen by inspection of the sights. In the revolver it is positive as is shown by the great height of the foresight. It is positive to the extent of about 10′ to 12′ in the Lee-Metford and Lee-Enfield rifles, while in the Short Lee-Enfield rifle it is also positive and about 6′ in amount. In the Snider it was negative. A heavy projecting bolt lever will produce some lateral disturbance of the direction given to the projectile. So will any weight attached to one side of the barrel. In the Martini-Henry, the attachment of the bayonet to the right-hand side of the barrel at the muzzle deflected the bullet some 10′ to 15′ to the left. The attachment of the bayonet below the muzzle in the ·303 rifle, has the effect of lowering the line of departure of the bullet, so that the 300 yards sighting gives about the proper elevation for 200 yards.

The bayonet is not fixed on the barrel of the Short Lee-Enfield rifle, but on the nose-cap only. Fixing the Pattern 1903 bayonet with a 12-inch blade has no effect on the elevation of the Short rifle; but the Pattern 1907 bayonet of the same weight, but with a 17-inch blade, causes a slight drop in the shooting, owing to the greater leverage it exerts when the rifle jumps on firing. The drop amounts to 4 inches at 300 yards range.

No rifle will shoot with absolute accuracy, even under the best circumstances. Leaving out of account the influences which affect the flight of the projectile after it has left the muzzle and which are dealt with in Chapter IV, Part II, it seems impossible to reproduce with absolute accuracy from one shot to another all the circumstances which precede the delivery of the bullet into the air. When it is considered how many variable elements are involved, it is perhaps to be wondered at that any degree of accuracy is attainable. The whole arm is actually moving, as has already been stated, when the bullet quits the barrel. However careful the manufacture, there are inevitably minute variations in size in the various parts of the cartridge. The weight of the bullet varies within small limits, so does that of the explosive and of the igniting charge in the cap. The rate of ignition is not always the same. The friction which the bullet encounters in the bore is not absolutely uniform; bullets vary slightly in diameter, and the resistance they meet with depends in part upon the condition of the surface of the bore. This does not remain uniform during the series of shots.

It is also certain that some rifles shoot more accurately than

others. Any unnatural "set" of the barrel, putting the particles of metal at some point in it, into a state of strain, may be taken to complicate the vibrations. It has already been mentioned that anything which grips the barrel tightly, will have the same effect. There are small differences in the diameter of the barrel and dimensions of the grooves, within the narrow limits allowed in manufacturing. These are probably in part accountable for the difference in accuracy between one rifle and another.

The capacity of military rifles to shoot accurately did not, until recent years, correspond even with the degree of accuracy of which the human eye and hand were capable. The usual mode of testing both rifles and ammunition is to attach the rifle to a mechanical rest and observe the size of the group made by a given number of shots. Such groups are of course much affected by wind and weather, and the shooting should if possible be carried out in a covered-in gallery. Comparisons drawn from single groups are apt to be misleading; the same rifle will often perform unequally, shooting in one series of shots very accurately, at another very indifferently, when all the circumstances seem to be exactly the same. The errors of aim made by a skilled shot, firing with fine sights from a rest, or in a steady position, are so small that a group of shots fired by him will not as a rule be materially larger than one obtained from the mechanical rest with the same rifle and ammunition.

The group of shots made by a good rifle is approximately circular, and at short ranges all the shots should be contained in a circle subtending about 3′ at the muzzle, the bulk of them being well in the middle of it. With ammunition giving irregular velocities, the group will tend to be somewhat elongated vertically and to be oval instead of round.

Under circumstances in which the flight of the bullet is not affected by wind, the group will usually consist of a well-packed central patch, in which the bulk of the shots are more or less evenly distributed, and from which the remaining shots have wandered decidedly in one direction or another. In the central part of the group the shots are distributed with fair regularity, and there is not the tendency which has sometimes been imagined for them to increase in frequency to the absolute centre of it. The experiment of firing a series of shots through a number of screens shows that the central shots of the group do not necessarily retain their relative positions through the whole course of their flight. This proves that the path of any given shot, though conforming on the whole closely to the theoretical path, makes small but irregular deviations from it. When firing at a series of thin paper screens, placed one behind the other, 25 yards apart, on each of which is a vertical line in the same plane as the line of sight, it is found that the distance from the vertical line of the

holes made by some of the bullets gradually increases and diminishes. This erratic deflection is probably due to an unsteadiness in the spin of the bullet, which causes the point to gyrate. The resistance of the air then acts with greater force first on one side of the bullet, then on another, and causes the bullet to deviate, making the trajectory assume a somewhat cork-screw form. Any shots which are wide of the central group will, as the range increases, usually be found to deviate from it beyond the strict proportion due to the distance.

One important factor affecting the shooting is the condition of the bore. As soon as the surface of the rifling loses its smoothness, whether from rust or wear, the accuracy suffers. The want of smoothness no doubt entails irregularity of friction. The enlargement of the barrel by wear likewise affects the regularity of the shooting, probably in part because the sealing of the bore against the passage of the gases is imperfect. This process of enlargement is mainly due to the erosion of the metal. In rifles of ·45 or larger bore, firing black powder, the pressures were not very high, and the metal was not materially affected by the action of the powder gases. The surface if scrupulously cared for, could be perfectly preserved for many thousands of rounds, and a rifle which had been in frequent use for several years showed practically no enlargement and no loss of accuracy. The case is very different with the small calibre rifle of the present day. The explosive, which burns under very high pressure, has a destructive effect upon the surface of the bore, especially towards the breech end. This effect is especially marked with propellants such as cordite or ballistite, which contain nitro-glycerine, because of the very high temperature at which they burn. The increased wear and tear which they cause is part of the price to be paid for their keeping qualities, and their stability under varying climatic conditions.

The lead or coned part from which the bullet passes into the rifling and which lies immediately in front of the cartridge case, first shows signs of damage. After one or two hundred rounds have been fired with cordite, slight wear begins to be discernible, the edges of the rifling get a little rounded, and the front edge of the "lead" is slightly smoothed off where it meets the lands of the rifling. With further firing, the destruction of this part of the bore continues at an increasingly rapid rate, until the lead is so much enlarged that it is impossible for the bullet to seal the bore as it enters the rifling, and the gases escape round it as it leaves the cartridge and before it has taken the grooving.

At the muzzle erosion is also active, though in a less degree because the pressures are less. It is evident that as the bullet quits the muzzle the gases escape round it with great violence, and particularly so when its base is only just clear of the barrel. Thus it will happen that at every shot a minute portion of the metal of the barrel is removed, and each time the damage is carried a little further back than the last. Thus there proceeds

a gradual enlargement of the bore from the muzzle backwards, while a much more rapid enlargement proceeds forwards from the part of the barrel in front of the chamber.

The following details of an experiment on the progress of erosion in the Lee-Enfield rifle with cordite ammunition show its general course.

When the experiment began the barrel took the ·303 plug.

1,000 rounds produced a very slight enlargement of the bore. The ·303 plug ran freely in the muzzle, and the ·304 plug entered the rifling at the breech $\frac{1}{8}$-inch, the lead being somewhat damaged.

After 3,000 rounds the ·304 plug would enter $\frac{1}{4}$-inch at the muzzle, and at the breech the ·303 plug $1\frac{1}{2}$-inch, and the ·304 plug more than $\frac{1}{8}$-inch. The rifling showed decided wear at the breech. The lead was now $\frac{3}{16}$-inch deep and decidedly eroded.

After 6,000 rounds, the ·304 plug entered the muzzle $\frac{7}{16}$-inch and the breech $1\frac{1}{4}$-inch, the ·305 plug entering the breech $\frac{1}{2}$-inch. The rifling was much worn at breech. The lead was now $\frac{7}{16}$-inch deep, the large cone and bevel of small cone $\frac{1}{32}$-inch deep. Erosion of the lead was increased.

After 9,000 rounds, the ·304 plug entered the muzzle $\frac{1}{2}$-inch and the breech $1\frac{1}{8}$-inch. The ·305 plug entered the latter $\frac{3}{4}$-inch, and the ·306 plug $\frac{1}{2}$-inch. The rifling was badly worn at the breech and considerably so at the muzzle. The lead was now $\frac{9}{16}$-inch deep, the large cone and bevel of small cone $\frac{1}{32}$-inch deep. The erosion at the lead was great.

After 12,000 rounds the state of the barrel was very bad. The ·304 plug entered the muzzle $4\frac{1}{2}$ inches, and the ·305 plug $\frac{3}{16}$-inch. At the breech, the ·304 plug would enter 19 inches, the ·305 plug $1\frac{1}{8}$-inch, the ·306 $\frac{7}{8}$-inch, the ·307 $\frac{3}{4}$-inch, the ·308 $\frac{7}{16}$-inch, the ·309 $\frac{3}{8}$-inch. The rifling was very badly worn at the breech and much worn at the muzzle. The lead was $\frac{3}{4}$-inch deep, and in fact destroyed. The bevel of the small cone (destroyed) was $\frac{3}{32}$-inch deep and the large cone $\frac{1}{32}$-inch deep. The erosion at the lead was bad. The rifle was now quite unfit for further use and the experiment ended.

The figure of merit, *i.e.*, the mean deviation of each of 2 groups of 10 shots at 500 yards, fired after every 1,000 rounds, is given below, and also the observed velocities at 90 feet from the muzzle. The gradual falling-off in accuracy and velocity will be noticed.

TABLE I.

	Figures of Merit in feet.	Velocity, 90 feet from Muzzle.
After 1,000 rounds ..	·68 ·69	2,012·2
„ 2,000 „ ..	·72 ·54	1,956·1
„ 3,000 „ ..	·76 ·65	1,992·8

TABLE I—*continued.*

	Figures of Merit in feet.	Velocity, 90 feet from Muzzle.
After 4,000 rounds ..	·84 ·61	1,985·0
„ 5,000 „ ..	1·01 ·77	1,983·5
„ 6,000 „ ..	·70 ·93	1,929·4
„ 7,000 „ ..	·99 ·69	1,922·6
„ 8,000 „ ..	1·14 ·78	1,944·6
„ 9,000 „ ..	1·10 ·75	1,921·9
„ 10,000 „ ..	·97 ·85	1,912·9
„ 11,000 „ ..	1·66 ·96	1,873 7
„ 12,000 „ ..	1·05 1·45	1,885·7

Throughout the experiment there was almost constantly present at the muzzle what is known as metallic fouling. This is a metallic deposit arising, it would seem, primarily from the envelope of the bullet, minute particles of which become deposited upon the rifling owing to the friction which takes place while the bullet passes along the bore. Bullets sheathed in Cupro-nickel will often leave in the muzzle, principally on the lands, a whitish streak, and those sheathed in copper a yellow streak, easily recognisable as corresponding with the material of which the envelope is made. It is possible that when erosion is proceeding rapidly, the metallic fouling may be increased by the deposit in the upper part of the barrel of particles of steel washed off from the breech end, and even of metal from the front part of the cartridge case. This metallic fouling accumulates under some circumstances sufficiently to reduce the diameter of the forepart of the bore by ·001-inch or more. It is evident that such a deposit must effect the amount of frictional resistance met with by the bullet in its passage through the bore. However it may arise, there can be little doubt that metallic fouling is undesirable when extreme accuracy is of importance. In rifles firing black powder and leaden bullets, it was found necessary, to prevent the deposit of lead on the surface of the bore, to wrap the bullet in a paper patch or to grease it heavily. The fouling or deposit of the products of combustion was likewise a great source of inaccuracy. The latter difficulty may now be said to have

disappeared, for the combustion of cordite leaves practically no deposit.

The effect of wind is by far the most difficult element to contend with in shooting at known distances. It affects elevation (see Chapter V, Part II) but its most material effect is in the lateral deflection of the bullet. Its influence on the flight of a projectile naturally varies according to the weight of the latter and the area on which the wind acts. Thus, the bullet of the ·303 weighs 215 grains and that of the Martini-Henry 480. But the surfaces which they expose to a side wind are approximately as 2 to 3; consequently *ceteris paribus* it would seem that the former should be much more affected by a side wind than the latter. And this is in fact the case, for the allowance to be made in a cross wind up to 1,000 yards is actually rather greater for the ·303 bullet, although it is in flight for a much shorter time. Thus for 1,000 yards the time of flight of the Martini-Henry bullet was considered to be 3·32 seconds, while that of the ·303 is about 2·37 seconds. The time during which the bullet is exposed to the motion of the air is therefore greater in the case of the former in the proportion of 7 to 5. It should further be noted that the bullet having the more curved trajectory rises to a greater height, and so usually into more rapidly moving air than the other, for the earth-drag impedes the free flow of the current.

As the angle made by the wind with the direction of the bullet varies, the proportionate effect on the range and on the lateral deviation will also vary. Unless the wind is approximately up or down the line of fire, or nearly at right angles to it, a combination of the two effects will have to be allowed for.

If we adopt the usual custom of referring the line of fire to the direction on a clock face from VI towards XII, a wind of a given strength will require for a given range very nearly the following proportionate allowances according to its direction, viz.:—

If from XI, I, VII, or V, it requires an allowance of 1 inch, then being of equal strength from

X, II, VIII, or IV, it will require 2 inches,

and if from IX, or III, it will require 3 inches.

The following table is calculated by Captain J. H. Hardcastle (late R.A.), for the ·303 rifle under normal conditions (initial velocity 2,000 f.s., barometer 30 in., thermometer 60° F.). It summarises the degree of variation in the weather conditions which will require a change of ± 1 minute of elevation at various distances up to 2,000 yards, and also the amount of change which will be met by varying the sighting 25 yards:—

TABLE II.

± 1-minute elevation is required to counteract a change of—					Range.	Normal elevation.	± 25 yards on sight is required to counteract a change of—				
± Range.	∓ Muzzle velocity.	Head or rear wind.	Rise or fall barometer.	Fall or rise thermometer.			Fall or rise thermometer.	Rise or fall barometer.	Head or rear wind.	∓ Muzzle velocity.	± Minutes elevation.
yards.	f. s.	miles per hour.	inches.	° F.	yards.	° ′	° F.	inches.	miles per hour.	f. s.	′
18	100	..	..	..	200	0 9½	..	..	..	140	1·4
12	33	40	2·2	36	500	0 30	77	4·7	85	70	2·1
11	25	30	1·8	29	600	0 39½	68	4·2	71	60	2·4
8·3	19	14	0·75	13	800	1 1½	39	2·3	42	57	3·0
7·5	15	10	0·6	10	900	1 15	32	2·0	33	48	3·3
6·9	12	7½	0·5	7	1000	1 29	27	1·7	27	43	3·9
6·4	10	6	0·4	6	1100	1 44½	23	1·5	23	39	3·9
4·8	7	3	0·12	2	1500	3 1	10	0·6	16	37	5·3
3·4	5	1½	0·033	0½	2000	5 13	3·3	0·25	11	36	7·4

Table of corrections for elevation.

The time of flight of a projectile for any distance depends both upon its initial velocity and upon the rate at which it loses its velocity. The latter is governed principally by the weight and diameter of the bullet, but will also be affected by its shape. The general shape of the curve of loss of velocity shows a steep inclination at the higher velocities, and a gradual one at the lower, the resistance of the air diminishing in a much more rapid proportion than the velocity.

In firing at an object in motion, the time of flight of the bullet must be taken into account, together with the interval between the actual instant at which the trigger is pressed and that at which the bullet quits the muzzle and commences its flight. The latter interval is very nearly constant, and consists of ·0405 seconds from the release of the sear to the impact of the striker on the cap, and of ·00129 seconds more to the exit of the bullet.

The following table will serve as a guide as to the distance that a mark in motion may be expected to traverse during the flight of a ·303 inch bullet at various ranges. The interval referred to above has been neglected in the table, and any allowance calculated on it will therefore be a "minimum":—

TABLE III.

Distance.	Rate of motion across line of fire. Miles per hour.			
	3 (= walk).	6 (= double).	9 (= trot).	12 (= gallop).
yards.	feet.	feet.	feet.	feet.
100	0·7	1·4	2·1	2·8
200	1·4	2·9	4·3	5·8
300	2·3	4·5	6·8	9·1
400	3·2	6·4	9·5	12·7
500	4·2	8·4	12·5	16·7
600	5·3	10·5	15·8	21·1
700	6·3	12·6	18·9	25·1
800	7·7	15·4	23·2	30·9
900	9·1	18·2	27·3	36·3
1000	10·4	20·9	31·4	41·8
1100	11·9	23·8	35·7	47·6
1200	13·4	26·9	40·3	53·8
1300	15·0	30·0	45·0	60·0
1400	16·7	33·4	50·1	66·8
1500	18·4	36·7	55·1	73·5
1600	20·2	40·4	60·6	80·8
1700	22·0	44·1	66·1	88·1
1800	23·9	47·9	71·8	95·7
1900	26·0	52·0	77·9	103·9
2000	28·0	56·0	84·1	112·1

The path of a projectile fired vertically downwards is a straight line, and continues in the same direction, the influences of the propellant, and of gravity being in the same direction. The opposite case is that of a projectile fired vertically upwards, when on the exhaustion of the velocity given by the propellant, it descends in the same line in which it rose. Between these two extremes all varieties of curve are found. It is very rarely that it is required to fire up or down hill at an angle exceeding 35°, and it is only at the shortest ranges that angles approximating to this amount are encountered. If the trajectory were a rigid curve the range for which elevation should be given would be the distance on the horizontal plane of the firer from a point, at which a perpendicular raised, or let fall from the mark, meets the plane. But at large angles of elevation such an assumption must not be made, and no general rule on the subject can be laid down, owing to the variation due to differences of velocity, and of mass and form of projectile. With the ·303 rifle and service charge the angles to be used on the sights for shooting up and down hill are approximately as follows for angles of 20°, 30°, and 40°.

Range.	Elevation on sights in minutes.			
	Horizontal.	20° slope.	30° slope.	40° slope.
yards.	′	′	′	′
200	9·5	9·0	8·5	7·5
300	16·0	15·0	14·0	13·0
400	23·0	22·0	21·0	18·0
500	31·0	29·5	27·0	24·0
600	40·0	38·0	36·5	33·0
700	50·5	47·0	44·0	40·0
800	62·0	57·5	54·5	50·0
900	74·0	70·5	67·0	63·0
1000	88·0	84·5	81·0	76·0

CHAPTER VIII.

Wounding Effect of Bullets.

The severity of the blow received from any moving body depends largely upon the "kinetic energy," or power of doing work, in virtue of its motion, possessed by that body, such "energy" depending on the weight of the body and the velocity with which it is moving at the moment of impact. This is a natural fact; but when we come to consider a particular case, as the effect produced on a man when struck by a small arm bullet, we find that the physical limits, within which we must work, are so restricted by practical considerations, other than wounding effect, that the importance of "striking energy" disappears, in comparison with that of several other factors that arise. Estimates of wounding effect under varying conditions are made from experience gained in actual warfare, or from the results of experiments carried out against the dead bodies of animals, and from such estimates it is difficult and dangerous to attempt to draw exact conclusions. The medical reports of one or other of the combatants at the close of a great war are of undoubted value; but a wounded man rarely can know at what range he was from the particular individual that shot him, and a surgeon can very rarely have the opportunity of observing two men of exactly similar muscular and bodily development, hit in an exactly similar manner by different types of bullets, striking them with the same velocity; thus details, essential to an exact conclusion, become largely a matter of guess work. Again, experiments on a dead animal produce results forming, no doubt, a good guide as to what would occur in the case of a living creature; but it would be dangerous to assume that the wounds produced in both cases are identical, or that an exact relation between them either exists or can be calculated. So any conclusions arrived at on the subject of wounding effect must be of a general nature, and should be considered as being liable to wide variations, and subject to the occurrence of many exceptional cases.

Up to the advent of the small-bore rifle below ·320 inch calibre, with its hard-coated bullet, there were no serious complaints of want of stopping power, but on the subject of the wounding power of small-bore bullets the greatest diversity of opinion has been expressed, and the subject is further complicated by the introduction of the very small-bore bullet, as the Japanese ·256 inch, and the pointed bullets now being employed by several nations. Again the increased velocities now being obtained with some new ammunitions have to be reckoned with.

Speaking broadly, the most important factors affecting the wounding effect of any bullet are *Velocity.—Shape.—Type of Envelope.*

It must not be thought from the above that such important properties as *weight* and *cross sectional area* are being lost sight of; but the effects of these upon the "ballistics" of the small arm are so vital that their dimensions are fixed, between somewhat narrow limits, by conditions quite independent of any question of wounding effect. This being so, their importance as regards the subject we are discussing diminishes considerably. It must also not be overlooked that the facilities, offered by the object struck, to the performance of work by the bullet, largely affect the nature of the wound produced, and that in some cases a very severe wound is not necessary; thus a bullet, travelling with a certain velocity, and striking a hard bone, would naturally be expected to inflict a more severe wound than if it merely traversed some soft, non-vital part of the human body, without meeting with any considerable resistance, while the extent or severity of a wound in a vital part would be immaterial.

We will now consider the wounding power of bullets according to the three main factors enumerated above.

Velocity.

The first effect attributable to *velocity* is the so-called "explosive effect," frequently observed in wounds. This is due to a cylindo conoidal bullet, travelling at a high rate of speed, striking a hard bone, or meeting with great resistance, in its passage through an object. The many splinters, into which the bone is broken, are driven forward by the bullet with great velocity, and themselves act as secondary missiles, producing great destruction in the neighbouring tissues, and make an enormous exit wound, such as would lead one to suppose that the bullet itself had exploded. This effect has occasionally been observed where soft parts only have been traversed, but such cases are exceptional. With rifles of the Martini - Henry class, such wounds might be produced up to 150 or 200 yards, and, on account of the leaden bullet setting up and becoming deformed on striking the bone, the explosive effect might be even more severe than that produced by the modern small-bore.

The modern small-bore rifle, on account of its higher velocity, may be expected to produce this "explosive effect" up to ranges considerably in excess of those mentioned above, and the very small-bore rifle will probably give somewhat similar results. From Russian experience against the Japanese ·256 inch bullet, the "explosive effect" seems to have been very marked and severe up to 200 paces, and effective up to 600 paces.

When soft parts are struck, bullets of the Martini-Henry type crush through the tissues, causing more laceration and shock than the small-bore bullet, with its higher velocity, which cuts through the flesh more cleanly, making a wound which often heals in a very short time.

At the longer ranges, the small-bore bullet and the ·450

produce bone fractures of about the same gravity. From 800 to 1,200 yards the fractures produced by the small bore are the less severe of the two. At ranges over 1,200 yards, the small-bore, on account of its retaining its velocity better, causes greater destruction in striking bones than the larger bullet.

At the longer ranges soft parts are more lacerated by the large-bore bullet; the latter may also complicate the wound by remaining in it.

Against the Japanese ·256 inch, it was found that from 600 paces to 800 paces there was practically no "explosive effect," the perforations being clean and rarely septic.

In experiments with the Mauser rifle bullet of ·311 inch diameter, it was found that the bullet never lodged in the tissues of the body at ranges up to 1,500 yards.

At very long ranges it is obvious that the small-bore bullet will still possess a certain wounding power after that of the ·450 has become negligible, on account of the difference of velocities between the two.

It will be seen that on the whole the small-bore bullet holds an advantage over the old large-bore. Though with equal velocities the wounds are no more severe, and, at medium ranges, on a soft non-vital part the effect of the large-bore may be greater than the clean perforation of the other, still the superior velocity of the small-bore largely increases the limit of range within which each nature of wound may be expected.

The *shape* of the ordinary small-bore bullet does not differ very materially from that of the old bullets of the Martini-Henry type, but the introduction of pointed bullets, on account of their power of retaining their velocity and the consequent flatness of trajectory that can be obtained with them, necessitates an examination of how the wounding power of the old round-nosed bullet compares with that of the pointed type. At ranges at which we may expect "explosive effect," the round-nosed bullet may be expected to be slightly superior to the pointed one for equal *velocities* as the shape of its nose is better adapted for the delivery of a "smashing blow," but against this we have to set the superior power of the pointed bullet to retain its velocity, so that, for equal *ranges*, the effect of the pointed bullet would be equal or superior to that of the other, while the limit of range at which any such effect could be expected is increased by the use of pointed ammunition. At long ranges, however, the pointed bullet shows superiority. It would seem that the pointed bullet is liable to turn over on impact, thus adding largely to the size and severity of the wound. We must not assume, however, that such behaviour is *entirely* confined to bullets of the pointed shape, as we read that the Russian experience against the Japanese ·256 bullet was that "from 800 to 1,000 paces the perforations were larger" (than at rather shorter ranges) "owing to the unsteadiness of the bullet, and at these distances, clothing, &c., was often carried into the wound, causing infection."

Shape.

Above all, in comparing the relative values of round-nosed and pointed bullets, we must remember that by employing the latter we are likely to produce *more* wounds, so that a marked superiority in wounding effect must be proved for the former if its retention is to be justified.

Envelope.

One of the great factors in the "stopping" power of the old lead bullet, was its ability to "set up" on meeting any considerable resistance. With the modern small-bore bullet with its hard envelope enclosing the soft, heavy, non-elastic material of the bullet proper, this property of setting up is liable to be lost altogether unless the details of the envelope are carefully considered. The material of the envelope must be of sufficient strength to withstand the stresses to which it is subjected in the bore of the rifle, while allowing of a certain amount of deformation, due to "setting up," on impact. The strain on the envelope, in the bore, will take effect round the sides of the bullet, while on impact it will be mainly on the nose, so that possibilities exist of varying the strength of the envelope at the desired points, of thinning it at the nose, to a degree sufficient to ensure safety from "stripping," while maintaining any desired thickness in the walls. Any such arrangement is more applicable to the round-nosed than to the pointed bullet, but it can be employed with a certain amount of effect, in the case of the latter. If a pointed bullet with the maximum armour-piercing power is required, the conditions are quite different and must not be confused with those applying to the "man stopping" bullet, which are here being considered.

Nothing has been said about expanding, or, as they are sometimes inaccurately called, explosive bullets, as their use in warfare among civilised nations has been declared inadmissible by the Hague Convention. In bullets of this class there is a break in the continuity of the hard metal envelope. In some examples the lead is exposed at the point of the bullet, in others the envelope is slit at the shoulders. There are many ways of making them, but the object is the same, namely to decrease the power of the bullet to retain its shape on striking a soft object. Such bullets, when travelling with a high velocity, either break up into numerous fragments and produce an explosive effect, or expand, on account of the point being driven back into the body of the bullet, and so increase its diameter and the size of the wound it causes. At long ranges, where the velocity is low, the shock of impact against flesh is not sufficiently great to alter the shape of an expanding bullet; it then causes no more damage than if its envelope had been continuous.

With expanding bullets the penetration increases with the range, as the expansion of the bullet decreases. The penetration is greatest at the range at which it first ceases to expand, and then diminishes as the range increases, on account of the velocity and energy falling off.

It must be remembered that ideas on the subject of small arm ammunition are at present in a state of change, calibres are, in some quarters, being reduced below the limit until recently considered the minimum, pointed bullets are being generally introduced, velocities are rising, and, in the meantime, data as to wounding effects remain meagre, so it would be unwise to form too definite conclusions or to consider that any finality has been arrived at.

We must not overlook the fact that the desired object is not to increase the severity or mortality of wounds in warfare, but to ensure that our small arm, as it increases in accuracy, rapidity of fire, and range, shall still possess a sufficient "stopping" power, without which it is entirely useless.

Taking the surgical results of the South African war, as a whole, it appears that, although terrible wounds have been caused by explosive effect, the small arm wounds have generally been more successfully treated than in the days of plain lead bullets. It is more common nowadays to hear of cures being effected when the abdomen or brain have been perforated than in the days of the ·45 bore. Although this satisfactory state of things must be partly attributed to the advance of scientific and surgical knowledge, and also to the increased range at which modern battles are fought, still the small-bore hard-coated bullet must be given its share of the credit in bringing about this humane result.

CHAPTER IX.

Revolvers and Automatic Pistols.

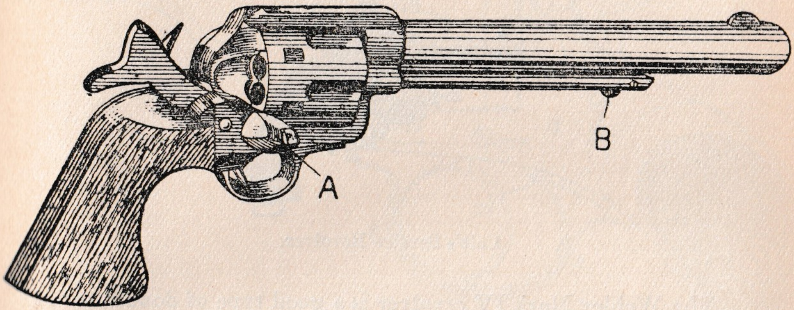
Firearms having a single fixed barrel, and a revolving cylinder, containing several chambers for the cartridges, were made as early as the sixteenth century. The cylinders of these arms were originally revolved by hand; but this was eventually improved upon by causing the pull of the trigger or the cocking of the hammer to do the work. In 1835, Colonel Colt patented his revolver, the chambers were loaded with powder and bullets from the front ends, and each chamber was provided with a nipple which had to be capped. At first American revolver makers caused the cocking of the hammer to revolve the cylinder, while the English makers effected this by the pull of the trigger. The English maker Adams, in 1855, brought out the double action revolver in which the revolution of the cylinder could be effected by both these methods. When the revolver is cocked and fired by pressing the trigger, a greater rapidity of fire is attained than when the hammer has to be cocked by drawing it back by the thumb, but the accuracy is impaired, as a long pull has to be given to the trigger and a certain amount of force has to be used, to compress the mainspring and revolve the cylinder. The double-action revolver was, therefore, a great advance, for the first shot could be accurately fired when the hammer was at full cock by a moderate pressure of the trigger; and the subsequent shots could be rapidly fired, if necessary by the trigger action.

As rim-fire, pin-fire and central-fire cartridges were successively introduced, revolvers were constructed to use them. The earlier forms of breech-loading revolvers had solid frames, an opening being cut in the right side of the shield behind the cylinder to allow of the cartridges being introduced into the chambers, and of the empty cases being ejected, this latter operation was effected by a rod attached to the revolver. The opening in the shield was closed by a swinging plate, controlled by a spring. In Fig. 18 of the Colts single-action revolver the Plate (A) is shown swung clear to allow of the cartridges being loaded into the chambers. The ejecting rod is carried in a tube attached to the barrel; it is kept pressed forward by a spiral spring, and is driven back so as to eject the empty cases by means of the fingerpiece B.

This method of extracting the fired cases was slow, and led to the introduction of self-extracting revolvers with jointed frames. In this type of revolver, the barrel is hinged to the frame at the front bottom corner of the latter; the barrel is

held in the firing position, by means of a strap, in prolongation of the barrel; the rear end of this strap is secured to the body

Fig. 18.

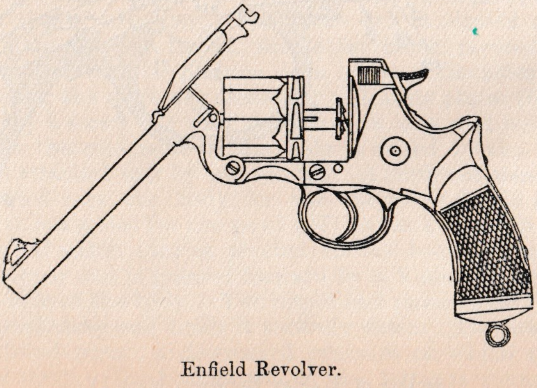


Colt's single-action revolver.

by a catch. The extractor consists of a plate engaging under the rims of all the cartridges in the chambers and is mounted on a central stem. On opening the revolver the extractor is forced to the rear, simultaneously extracting all the cases. See description of Webley revolver, page 151.

The above is the most usual form of jointed frame self-extracting revolver. An older form is the Enfield revolver (see Fig. 19). In this revolver on opening the barrel catch and depressing the muzzle, the cylinder is drawn forward parallel to its original direction; the extractor only moves forward a short distance so that the empty cases are drawn out of the chambers, they have however to be shaken clear of the revolver.

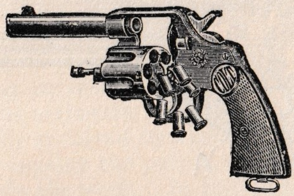
Fig. 19.



Enfield Revolver.

Another type of self-extracting revolver is the Colt's service revolver with solid frame. In this revolver the cylinder is swung out to the left and all the cartridges are simultaneously extracted (see Fig. 20).

Fig. 20.

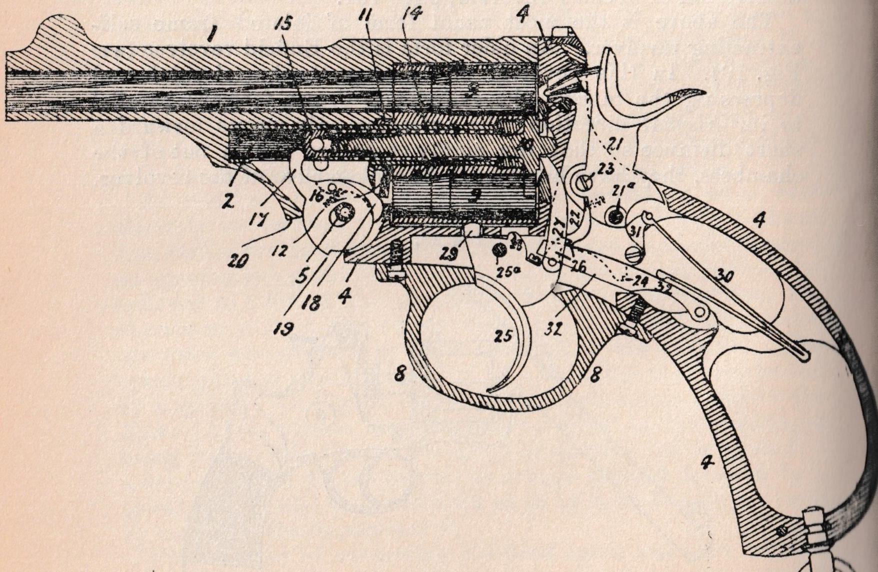


Colt's Service Revolver.

The Webley Mark IV revolver is a good type of double-action self-extracting revolver with jointed frame. The following is a short description of its principal features.

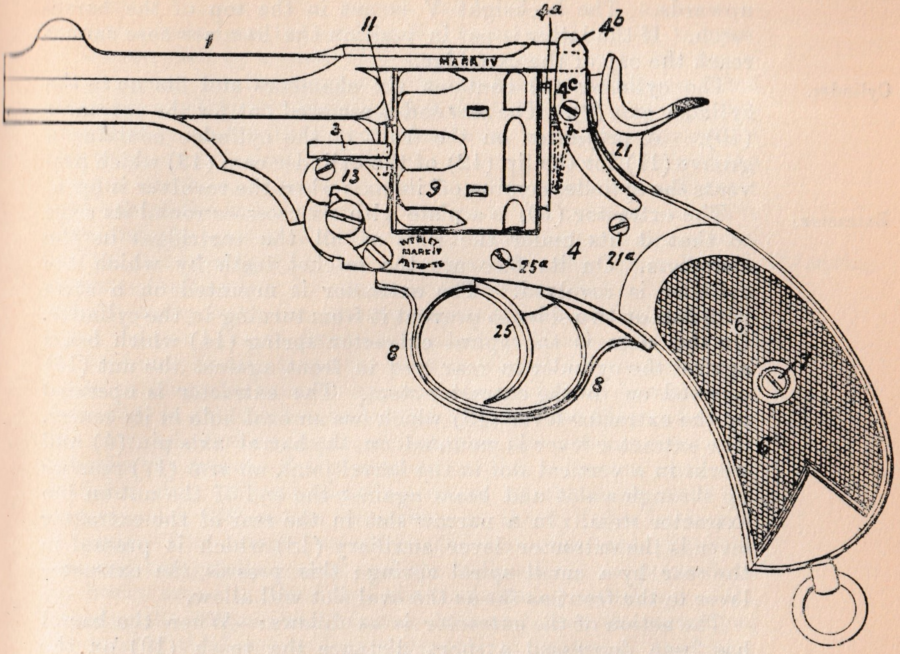
Webley Revolver, Mark IV. ·442 *inch bore* ; 6 *shot.*

Fig. 21.



Section of Webley Revolver, Mark IV.

Fig. 22.



Webley Revolver, Mark IV.

The barrel (1) is ·442 inch bore rifled with seven grooves, the foresight forms part of the barrel, the latter is extended to the rear in the form of a strap. Beneath the barrel is a projection forming the joint; in this projection the cylinder axis (2) is fixed parallel to the barrel. The holster guide (3) prevents the cylinder catching when putting the revolver in the holster. Barrel.

The body (4) contains the action, forms the stock and supports the bases of the cartridges. The front end is slotted out and forms a joint for the barrel, the latter being pivoted on an axis pin (5) retained in position by a screw. The sides of the body forming the stock are closed by vulcanite plates (6), held together by a screw (7) with countersunk cup and nut. The opening in the underside of the body is closed by the trigger guard (8) attached to it by two screws. A hardened steel shield (4*a*) is fitted into the body for the cartridge heads to bear against; it has a slot for the pawl (27) to work through. Body.

The barrel catch (4*b*) is pivoted to the body by the screw (4*c*); its upper end is pressed forward by a V-shaped spring on the right side of the body. The upper end passes over the end of the barrel strap and holds it securely down. The lower end forms a thumb piece; a downward pressure on which releases the barrel strap. The bottom end of the latter is rounded off, Barrel catch.

so that it can snap into position on the barrel being jerked upwards. The backsight V is cut in the top of the barrel catch. If the latter is not in position the hammer nose cannot reach the cap of the cartridge.

Cylinder. The cylinder (9) contains six chambers and fits on to the cylinder axis (2). The rear end is recessed out for the extractor (10). A projection on the front of the cylinder contains a groove (11) for the lip (12) of the cylinder cam (13) which prevents the cylinder coming off its axis when the revolver is open.

Extractor. The extractor (10) is a plate with six recesses round its edge so that it fits under the rims of all the cartridges in the chambers. On its face are the ratchet teeth by which the cylinder is revolved. The extractor is mounted on a stem with flats on two sides to prevent it from turning in the cylinder. On the stem is the spiral extractor spring (14) which bears against the cylinder in rear and in front against the nut (15) screwed on to the extractor stem. The extractor is operated by the extractor lever (16) which has an oval hole in its centre. The extractor lever is mounted on the barrel axis pin (5) and works in a vertical slot in the barrel joint, an arm (17) reaches up through a slot and bears against the end of the nut on the extractor stem. In a narrow slot in the rear of the extractor lever is the extractor lever auxiliary (18) which is pressed to the rear by a small spiral spring; this presses the extractor lever to the front as far as the oval slot will allow.

The action of the extractor is as follows:—When the barrel has been depressed a short distance the tooth (19) on the extractor lever catches against the bottom of the body and arrests the motion of the extractor lever. The arm (17) of the extractor lever in its turn arrests the motion of the extractor stem; therefore as the barrel and cylinder are revolved forwards and downwards the extractor is forced out of the cylinder and ejects the cartridges; but as the barrel approaches its lowest position, the corner (20) of the barrel joint passing over the tooth (19) presses it to the rear, and when it has forced the tooth (19) into the groove in the body, the extractor lever is free to rotate. The extractor spring then re-asserts itself, driving the extractor home and causing the extractor lever to rotate on the axis pin.

Hammer. The hammer (21) is pivoted on the screw (21*a*), its nose passes through an opening in the body so as to be able to strike the cap of the cartridge in the uppermost chamber. The hammer catch (22) is pivoted on the screw (23); it is pressed forward by a small spiral spring carried in a recess in the hammer. The bent (24) in the hammer is used when the weapon is used single action, *i.e.*, when cocked by hand before pressing the trigger.

Trigger. The trigger (25) is pivoted on the screw (25*a*); at the rear end is the trigger nose (26). Along side the trigger nose is pivoted the pawl (27). On top of the trigger is the cylinder stop (28) which enters into the six elongated grooves on the

outside of the cylinder, and prevents the pawl from rotating the latter too far. The trigger catch (29) is a separate component pivoted on the screw (25*a*) in a recess in the trigger; it is controlled by a small flat spring screwed on to the top of the trigger. As the trigger is drawn back, the trigger catch descends slightly and bears against the front part of its opening in the body, and as the trigger continues to revolve, the end of the trigger catch spring slips into a notch near the axis of the trigger catch, and causes its front end to start up and enter into one of the small external recesses in the cylinder, which is then entirely prevented from moving until the pawl again acts.

The mainspring (30) has two branches, the upper branch operates the hammer by means of the swivel (31). The lower branch rests upon the mainspring auxiliary (32) which bears upon the pawl just in front of its pivot and so keeps it pressed to the front; it also keeps the trigger pressed downwards. Mainspring.

On cocking the hammer by hand the projection in which the bent (24) is cut, catches under the trigger nose (26) and raises the rear end of the trigger; this causes the pawl to rotate the cylinder by means of the ratchet on the extractor until the cylinder stop (28) arrests the motion; at the same time the trigger catch (29) enters its seating in the cylinder holding it securely. The trigger nose then falls into the bent (24), the hammer being fully cocked and the mainspring compressed, as its lower arm is raised by the mainspring auxiliary. On pressing the trigger the hammer falls and fires the cartridge; the head of the hammer then rests against the top of the body. On releasing the trigger the mainspring auxiliary is lowered and the hammer head falls back a short distance from the body. Action of mechanism.

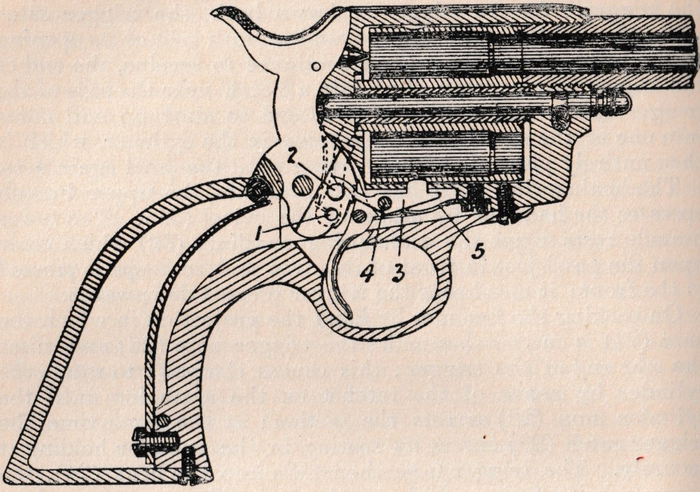
On pressing the trigger in order to fire without previously cocking the hammer, the trigger nose (26) bears against the bottom of the hammer catch (22) and causes the hammer to rotate. The pawl, cylinder stop, and trigger catch act as before. When the cylinder is revolved so that the next chamber is opposite the barrel, the end of the hammer catch slips off the trigger nose and the hammer falls as before. In both cases when the pressure of the finger on the trigger is released the trigger nose (26) presses the hammer catch (22) inwards so as to get past it.

Colt's Single-action Revolver, 6 shot.

The Colt single-action 6-shot solid frame army revolver is shown in Fig. 23. In Fig. 23 the pawl is shown in dotted lines pivoted on the pin (1). On cocking the hammer with the thumb, the pawl rotates the cylinder, and a short pin (2) on the hammer, lifts the tail of the cylinder stop (3) which is pivoted on the pin (4) so that the cylinder is free to revolve. As the hammer approaches the full cock position, the tail of the

cylinder stop (3), slips off the pin (2), and its tooth enters its groove in the cylinder, being forced up by the spring (5), and

Fig. 23.



Colt's Single Action Army Revolver.

arrests the motion of the cylinder. On pressing the trigger the hammer falls and fires the cartridge. As the hammer falls the end of the pin (2), which is bevelled off underneath, presses the tail of the cylinder stop (3) to one side and passes it. The tail of the cylinder stop is thin, and spring tempered, to allow of a small side play.

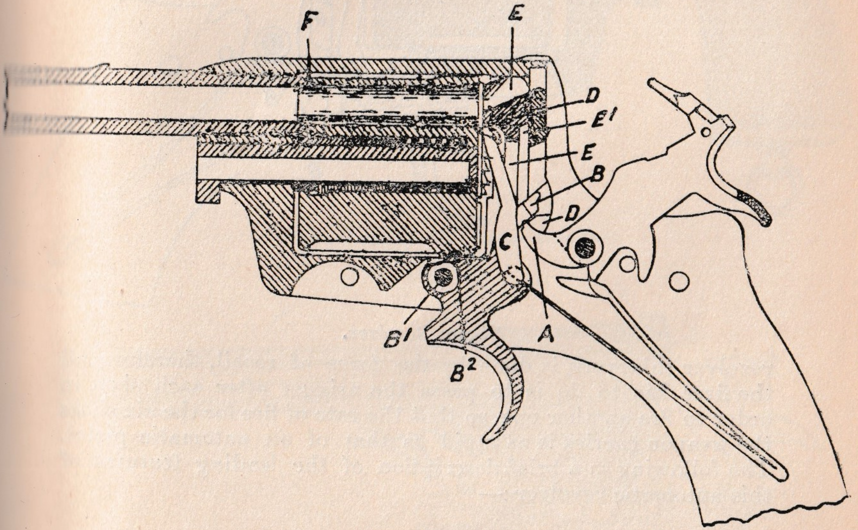
One great disadvantage of revolvers is the escape of gas at the opening between the breech end of the barrel and the cylinder. This corrodes the surrounding parts and materially diminishes the pressure in the barrel, and the consequent velocity of the bullet. This disadvantage has been overcome in the Nagant revolver, see Figs. 24, 25, adopted by Russia, by employing a long cartridge case, which extends a little beyond the nose of the bullet, so that when the cylinder is given a forward motion the end of the cartridge case enters the barrel and bridges the gap between barrel and cylinder.

The Nagant revolver is not double action, as a considerable amount of work has to be done while cocking the hammer, such as pressing the cylinder forward against the action of the spiral spring at its axis, forcing the resistance plate (D) up, and the breech piece (E) forward, besides compressing the mainspring; therefore the pull on the trigger would be too heavy if the above operations were done by trigger action. The following is a description of the manner in which the obturation, or sealing of the escape of gas between the cylinder and barrel is effected.

Nagant Revolver. ·3 bore; 7 shot.

In Fig. 24 the Nagant revolver is shown ready for firing; in Fig. 25 the revolver has been fired, and the pressure of the forefinger has been released from the trigger. On cocking the hammer, which is done by the thumb on the comb, the nose (A) lifts the arm (B) of the trigger, causing the latter to rotate on its axis pin (B^1); the pawl (C) engages the ratchet at the end of the cylinder, and rotates it until the trigger stop (B^2), engaging in its recess in the cylinder, arrests its rotation. The cylinder is then pushed forward by the pawl, and the end of the barrel, which is bevelled off, enters the mouth of the topmost

Fig. 24.



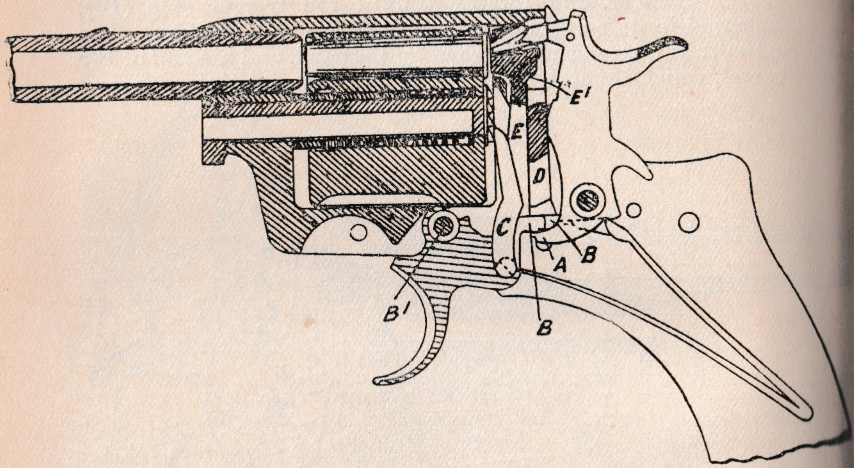
Nagant Revolver.

chamber in the cylinder. The cartridge case, which extends just beyond the nose of the bullet, enters the rear end of the barrel, and bridges over the junction between the barrel and cylinder, so that on firing very little gas is able to escape, see (F), Fig. 24. While the hammer is being cocked the trigger arm (B) raises the resistance plate (D), which moves in vertical grooves in the body. The top part of the resistance plate (D) strikes against the angle (E^1) of the breech piece (E); the latter, which forms the top end of a lever which is pivoted at its bottom end, is forced to move forward against the head of the cartridge, which it supports. The resistance plate (D) continues to rise, and forms a support for the rear face of the breech piece E when the cartridge is fired. On pressing the

trigger the hammer falls and fires the cartridge. On releasing the pressure of the forefinger on the trigger the parts assume the position shown in Fig. 25, the cylinder being pushed back by the spiral spring round its axis.

In all non-automatic revolvers the hammer is cocked and the cylinder rotated, either by cocking the hammer by hand, or by drawing back the trigger. In the Webley-Fosbery *automatic*

Fig. 25.



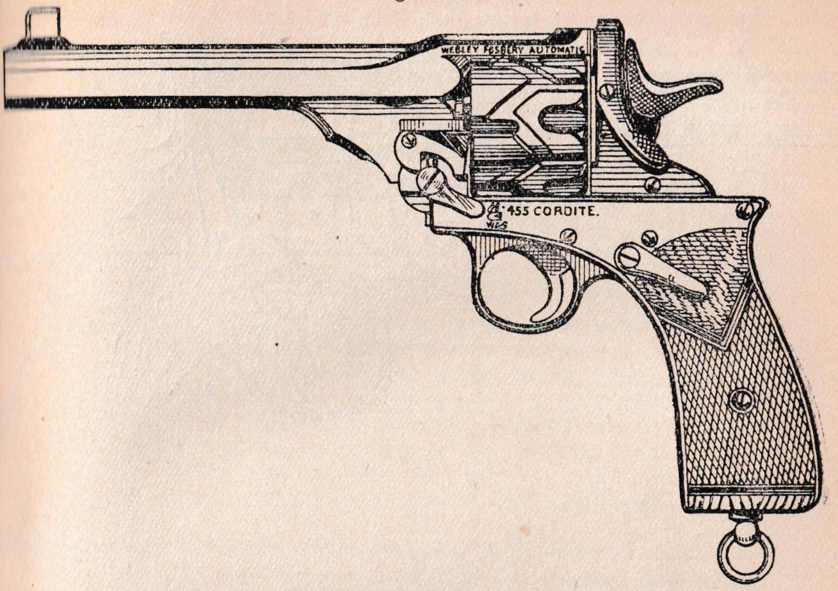
Nagant Revolver.

revolver this work is done by the force of recoil, therefore all the firer has to do is to press the trigger after each shot, in order to fire another one, so that the rate of fire for the six shots the weapon carries is as rapid as that of an automatic pistol. The following is a brief description of the leading features of this automatic revolver:—

Webley-Fosbery Automatic Revolver. ·442 *bore;* 6 *shot.*

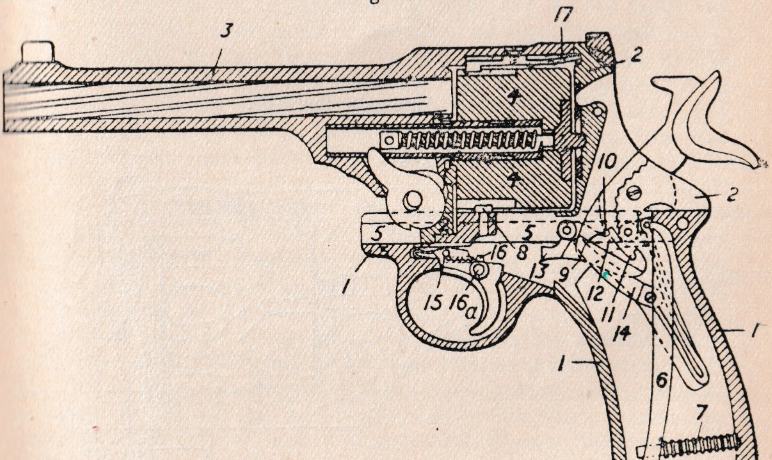
This revolver consists of the non-recoiling frame forming the handle (1) and trigger guard, and the recoiling parts shown in Figs. 27, 28, 29, consisting of the body (2) to which the action is attached, the barrel (3), and the cylinder (4). The body slides in a groove (5) on top of the frame, and is kept pressed forward by means of the recoil lever (6), which in its turn is actuated by the recoil spring (7). Within the groove on top of the frame is a projection into which is fixed the rotating stud (8). This stud works in zig-zag grooves cut on the external surface of the cylinder. The latter, in other respects, is similar to that of the Webley revolver. The extractor and barrel catch are also similar.

Fig. 26.



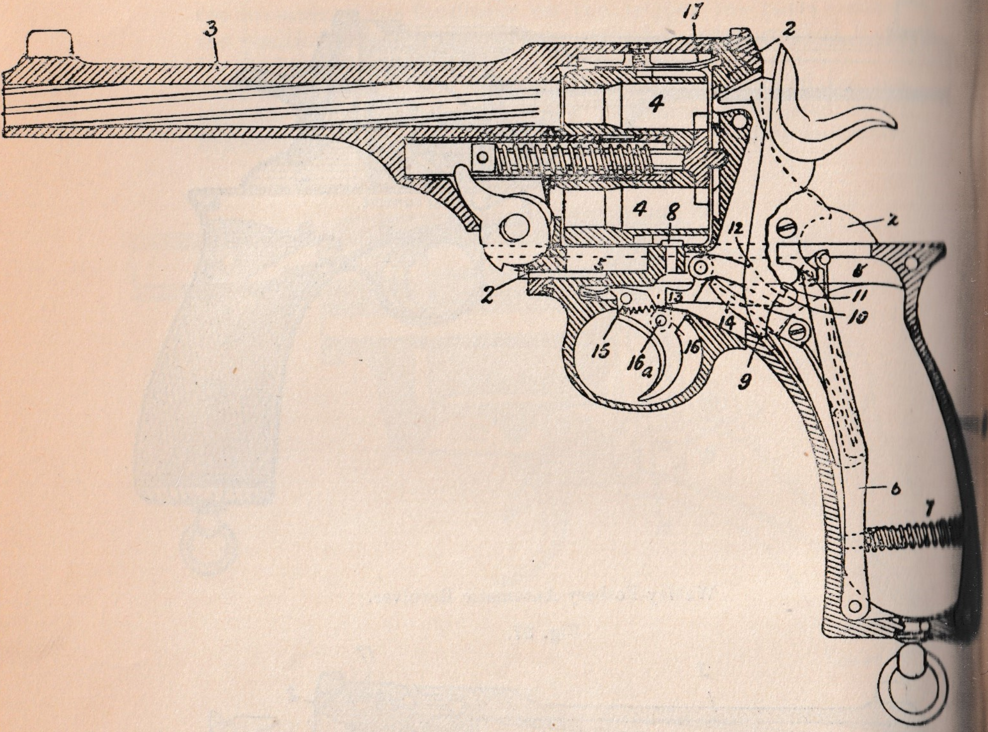
Webley-Fosbery Automatic Revolver.

Fig. 27.



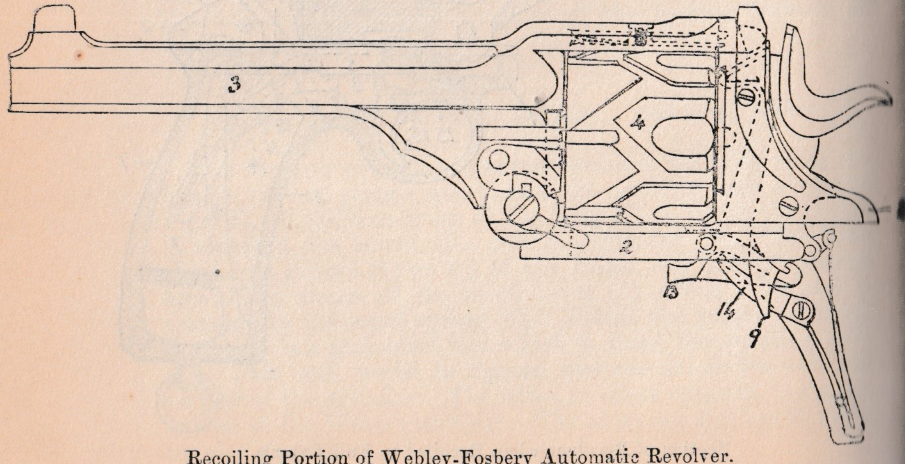
Section of Revolver when Recoiled to Full Extent.

Fig. 28.



Webley-Fosbery Automatic Revolver.

Fig. 29.



Recoiling Portion of Webley-Fosbery Automatic Revolver.

The hammer is provided with a tail (9) and a bent (10).

The sear has a half-cock bent (11), a full-cock bent (12), and a projecting arm (13) for engagement with the trigger.

The mainspring is similar to that of the Webley revolver. The short arm rests in a bent in the mainspring auxiliary (14), and presses the latter upwards, which, in its turn, bears against the sear and presses that upwards.

The trigger is pivoted on a screw (15) at its forward end, where a small V spring bears, keeping the trigger pressed down. In a recess in the top surface of the trigger the trigger catch (16) is pivoted on the screw (16*a*). The trigger catch is capable of revolving slightly on the screw (16*a*) ; it is provided with a small tooth on top, which engages with the end of the sear (13). A small spiral spring and plunger in the trigger keep the tooth of the trigger catch pressed to the rear.

A spring (17) is screwed on to the barrel strap. On the underside of the rear end of the spring is a tooth which, when the revolver is open, engages in the grooves in the cylinder and ensures the latter being in the correct position for closing. When the revolver is closed the rear end of the spring is raised so that the cylinder is free to be rotated by the stud (8).

Action of the mechanism.

Suppose the weapon to be loaded and the hammer cocked. On pressing the trigger the tooth of the trigger catch raises the end of the sear (13) ; this disengages the bent of the sear (12) from the hammer bent (10) and the hammer falls and explodes the charge. The recoiling parts are driven back, the body (2) sliding back in the groove (5) on top of the frame (1). The tail (9) of the hammer strikes a cocking stud in the frame, and is brought to full-cock, in which position it is retained by the bent (12) of the sear. The rotating stud (8) passes down one of the diagonal grooves towards the front end of the cylinder, and rotates the latter half the requisite amount. The recoil lever (6) then forces the recoiling parts forward again. The rotating stud (8) then passes down another diagonal groove and completes the rotation of the cylinder, bringing another chamber in line with the hammer and the barrel. As the recoiling parts complete their forward movement the end of the sear (13) strikes the tooth of the trigger catch and presses it forward. In order to fire another shot, the pressure of the forefinger on the trigger must be released ; the latter then rotates on its axis, downwards and forwards, so that the tooth of the trigger catch flies back under the impulse of its spring and plunger, and places itself beneath the end (13) of the sear. On again pressing the trigger the revolver is fired, and the above described actions are repeated.

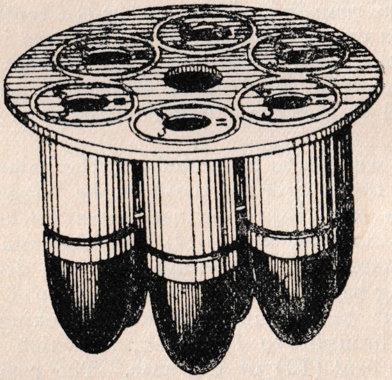
Safety bolt.

There is a safety bolt with thumb piece on the left side of the pistol. On raising the thumb piece the recoiling parts are forced slightly to the rear, so that the sear (13) is moved away from the tooth of the trigger catch, therefore pressure

on the trigger will not operate the sear. It also locks the frame to the recoiling parts.

The reloading of revolvers, particularly those that are not self-extracting, is very slow as compared with automatic pistols, which are reloaded by refilling the magazine by means of a charger, or introducing another loaded magazine. Hitherto the chambers of revolvers have been reloaded one at a time, but with a view of shortening the time occupied in reloading, Messrs. Webley have introduced a clip loader for the six cartridges required for reloading all the chambers of an automatic revolver at once. This is effected by fixing the bases of the cartridges in a disc of brass, which holds the cartridges in the required position.

Fig. 30.



The Webley Patent Clip Loader.

Automatic Pistols.

We will now consider automatic pistols. Weapons of this type are provided with one barrel, which contains the chamber for the cartridges, the latter being contained in a magazine, one above the other. The pistols are so constructed that the force of recoil is employed to open the breech, extract the empty case, cock the pistol, reload the chamber with the top cartridge from the magazine, and close the breech, leaving the pistol ready to fire on again pressing the trigger.

In all automatic pistols that have emerged from the experimental stage, except the Mannlicher model, 1894,* the breech

* In this pistol the base of the cartridge is supported by a fixed breech block; the barrel is drawn forward by the friction of the bullet and ejects the empty case. A special spring then forces the barrel to the rear, the top cartridge from the magazine entering the chamber.

is closed by a bolt, which is capable of a backward and forward motion in line with the axis of the barrel. These bolts often have a straight pull rectilinear movement, in which case they are generally not circular in section like the ordinary magazine rifle bolt.

Automatic pistols may be divided into two classes, viz. :—

Class I.—Those in which the breech bolt is locked to the barrel or frame when discharge takes place, so that the base of the cartridge is rigidly supported.

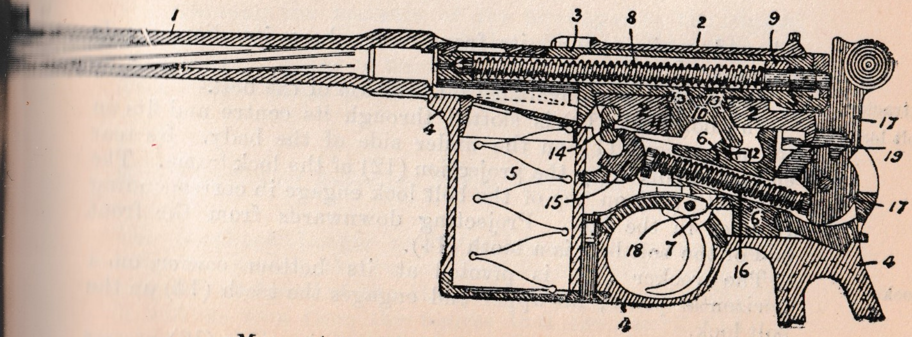
Class II.—Those in which the backward motion of the cartridge is merely checked by the inertia of the breech bolt, and the resistance of the recoil spring and hammer, for a sufficient time to enable the bullet to clear the muzzle before the cartridge is extracted from the chamber. In this class the barrel is usually fixed. This type of weapon is only suitable for firing small charges, and is more adapted for house protection than for military use against savages; it will not, therefore, be considered in the following remarks. It is evident that with this method of closing the breech, should an obstruction occur in the barrel, the cartridge case and gas would be blown out to the rear.

Before discussing automatic pistols generally we will briefly describe three of the best known examples of Class I: the Mauser pistol, used in the German army, the Borchardt-Leuger, used by the Swiss, and the Colt pistol.

Mauser Automatic Pistol. ·3 *bore*; 10 *shot.*

The Mauser pistol consists of a barrel (1) continued to form a body (2); the latter contains the bolt (3). The barrel and body slide on ribs on the top edge of the frame (4). The front part of the frame contains the magazine (5). The rear

Fig. 31.

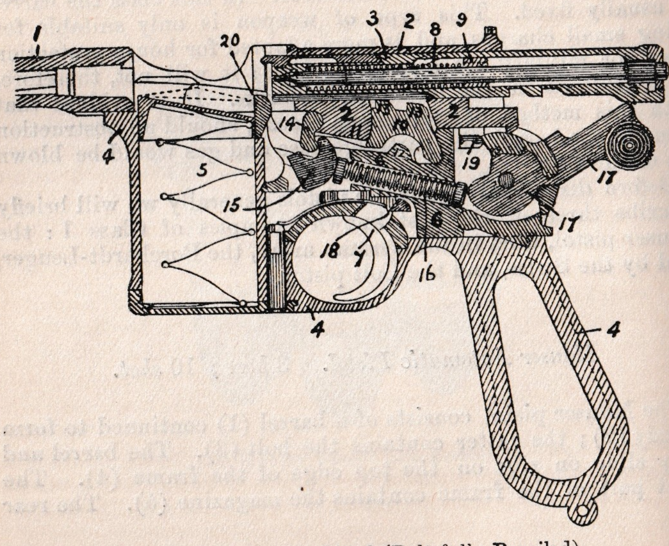


Mauser Automatic Pistol in Fired Position.

part of the frame contains the lock frame (6) and lock work. The frame is continued downwards to form the stock. The trigger (7) and trigger guard are at the underside of the frame.

Bolt. The bolt (3), which is square in section, slides backwards and forwards in the body. It is kept pressed forward by the spiral bolt spring (8) which bears against the front end of its chamber in the bolt, its rear end resting against the block (9) which is fixed in the body and inserted into the bolt through a long slot in its right side. The striker passes through an opening in this block. It is kept pressed back by a spiral

Fig. 32.



Mauser Automatic Pistol (Bolt fully Recoiled).

rebound spring round its front end, where its diameter is reduced.

Extractor. The extractor is dovetailed into the top of the bolt.

Bolt lock. The bolt lock (10) is slotted through its centre and fits on the projection (11) on the under side of the body. Its rear end is supported by the projection (12) of the lock frame. The two teeth (13) on top of the bolt lock engage in corresponding recesses in the bolt. Projecting downwards from the front end of the bolt lock is a tooth (14).

Rocker. The rocker (15) is pivoted at its bottom corner on a horizontal pivot; its upper end engages the tooth (14) on the bolt lock.

Mainspring. The plunger at the front end of the mainspring (16) presses

the rocker forwards. The plunger at the rear end of the mainspring operates the hammer (17).

The nose of the trigger engages the bottom end (18) of a lever which is pivoted to the sear. It is pressed forward by a small V spring not shown in the drawing. Trigger.

The sear is a flat horizontal plate, pivoted at its front end. The rear end (19) projects in front of the hammer and forms the bent of the sear. Sear.

The magazine (5) holds 10 cartridges, and is filled from a charger holding that number. The platform is pressed upwards by a zig-zag spring of ribbon steel. The bottom of the magazine is removable. Magazine.

Suppose the chamber to be loaded and the magazine full. On pressing the trigger, the trigger nose raises the lever (18) which, in its turn, raises the sear (19) and allows the hammer to fall on the striker and fire the cartridge. As it does so the nose of the trigger slips forward off the end of the lever (18); therefore the sear is able to fall and is ready to engage the hammer again. The explosion of the charge drives the barrel, body and breech bolt back $\frac{3}{16}$ inch, so that the rear end of the bolt lock (10) is no longer supported by the lock frame (12). The tooth (14) being pressed forward by the rocker (15) causes the bolt lock to drop, so that its teeth no longer engage the bolt. The latter, on account of its momentum, continues to move backwards, compressing the bolt spring (8) and cocking the hammer. When the bolt is fully back the empty case, which has been carried back by the extractor, strikes a projection (20) on the lock frame and is ejected. Action of the mechanism.

The bolt spring now re-asserts itself and drives the bolt forward, pushing the top cartridge from the magazine into the chamber.

The mainspring (16) presses the rocker forward, which in its turn acts on the tooth (14) of the bolt lock and forces the barrel and body forward. The rear end of the bolt lock mounts the inclined face at the back of the projection (12). This raises the bolt lock and causes the teeth (13) to again lock the bolt.

On releasing the pressure of the forefinger on the trigger, the nose of the latter pushes back the end of the lever (18) and so gets under it, ready to fire the next shot.

This weapon is sighted from 50 to 1,000 yards.

Borchardt-Leuger Automatic Pistol. ·301-*inch bore ; 8 shot.*

The Borchardt-Leuger or "Parabellum" automatic pistol belongs to Class I, the breech bolt being solidly supported during the explosion of the charge by the toggle joint (3) (4).

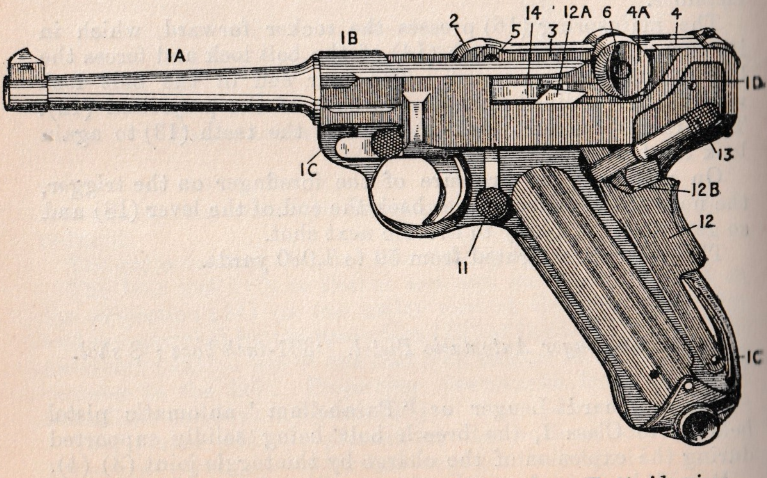
It will be seen from the figures that the barrel (1A) is screwed into a body (1B), consisting of two side pieces which

slide backwards and forwards in the frame (1C) or non-recoiling part. The bolt (2) slides in grooves in the body; it is supported in the firing position by the links (3 and 4) of the toggle joint, the front link being pivoted by the pin (5) to the breech bolt; the pin (6) joins the two links together, and the pin (7) connects the rear link to the body. The centre of the pin (6) is below the centres of the pins (5 and 7), when the breech is closed, therefore there is no danger of the toggle joint bending and the breech opening prematurely. The rear link (4) has a swivel (9) pivoted to it, the bottom end of which is hooked on to the recoil spring (10). Inside the bolt is the firing pin (8) actuated by a spiral spring. A projection (8A) on the firing pin projects through the left side of the bolt; it is engaged and held back by the sear till the trigger is pressed; it is also drawn back and cocked by the claw (3A) at the front end of the link (3). The breech bolt is provided with the usual claw extractor, and an ejecting stud is provided in the body.

The sheet metal magazine, with platform and spiral elevating spring, is introduced through the bottom of the hollow stock; it is retained in position by the catch (11). On pressing the roughened stud on the end of this catch the magazine is easily withdrawn and another inserted.

The automatic safety catch (12) projects through the rear part of the stock, and is operated by gripping the stock; the top end of it (12A) prevents the sear (14) from being disengaged from the projection (8A) on the firing pin until the stock is gripped for firing.

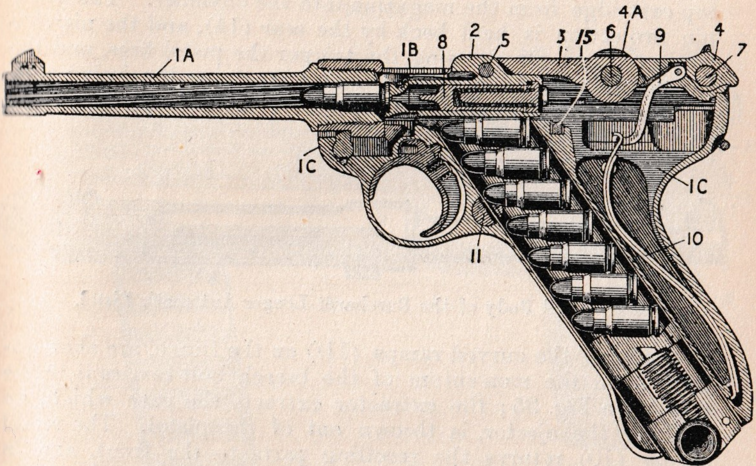
Fig. 33.



Borchardt-Leuger Automatic Pistol. Left side view. Butt side-piece taken off. Safety catch disengaged.

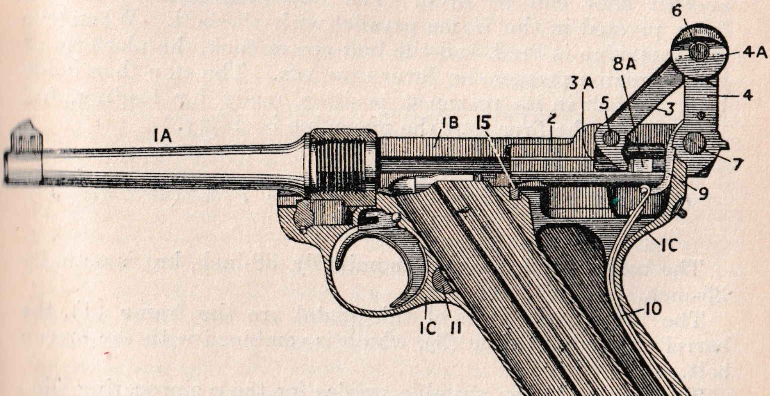
The safety catch (13) is pivoted to the frame (1C); when the back end is pressed up the front end is lowered and hooks in front of a projection (12B) on the automatic safety catch, and prevents the pistol being fired until it is disengaged.

Fig. 34.



Borchardt-Leuger Automatic Pistol.

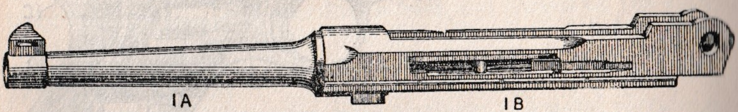
Fig. 35.



Borchardt-Leuger Automatic Pistol.

To load the pistol a full magazine is inserted in the stock; the cheeks (4A) of the toggle joint are gripped by the thumb and finger and jerked backwards; the toggle joint bends as in Fig. 35, draws back the breech bolt, and cocks the firing pin. On releasing the toggle joint the recoil spring (10) forces forward the barrel and body and straightens out the toggle joint which forces the breech bolt home; the latter drives the top cartridge from the magazine into the chamber. The firing pin projection is held back by the sear (14), and the pistol is ready to fire. On pressing the trigger the pistol fires, and the barrel and body recoil a short distance, giving the bullet time to pass out of the barrel; the cheeks (4A) of the toggle joint,

Fig. 36.



Barrel and Body of the Borchardt-Leuger Automatic Pistol.

on striking the curved ramps (1D) on the frame, are shot upwards, and the momentum of the breech bolt carries it to the rear as in Fig. 35; the extractor extracts the case which, on striking the ejector, is thrown out of the pistol. The recoil spring (10) returns the recoiling parts to the front, and in doing so reloads the barrel with the top cartridge from the magazine. On releasing the pressure of the forefinger on the trigger, the latter is put in communication with the sear and another shot can be fired. The stop (15) forms part of a lever pivoted in the frame parallel with the bolt. When the last cartridge is fired, and the bolt comes back, the platform of the magazine presses the lever upwards. The stop then holds back the bolt in its rearmost position, ready for loading, and indicates to the firer that the magazine is empty.

Colt's Automatic Pistol. ·38-*inch bore;* 7 *shot* (*Browning's Patent*).

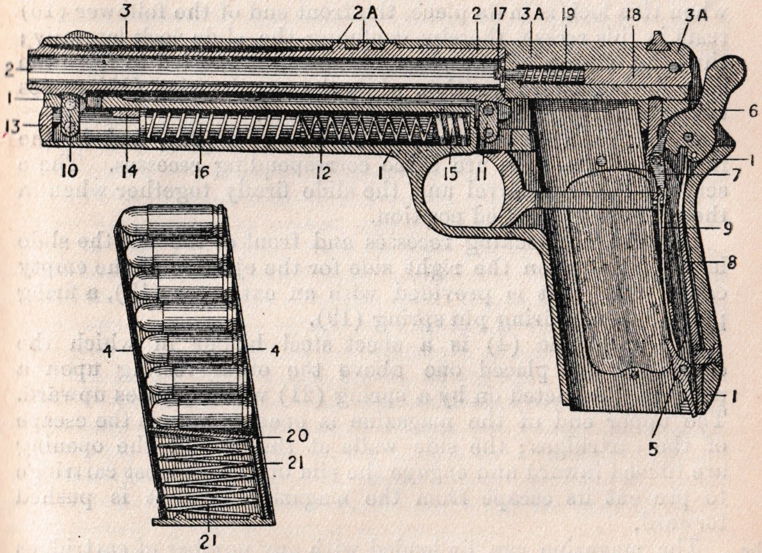
The bore of this pistol is nominally ·38-inch, but is actually ·35-inch.

The three main parts of this pistol are the frame (1), the barrel (2) and the slide (3), which is combined with the breech bolt.

The frame (1) has suitable guides for the reciprocating slide (3), and below is the handle which is hollow and encloses the cartridge magazine (4). This is inserted in the handle from below and is there held by the magazine catch (5), which slightly projects from the bottom of the handle; this projection serves to release the magazine from the catch, when it may be reedily drawn from the handle for recharging.

In front of the handle is the trigger guard in which the trigger is located; in the rear and above the handle is arranged in the frame the firing mechanism, consisting of the hammer (6), the sear (7), a safety device and the mainspring (8); also the sear, safety and trigger spring (9). The lower part of the latter serves to actuate the magazine catch.

Fig. 37.



Colt's Automatic Pistol, ·38 bore.

The top of the frame (1) extends forward from the handle, and to it the barrel is attached by two short links, one near the front end of the barrel (10) and one at its rear end (11); these links are attached to the frame by a link-pin and also to the barrel by a similar link-pin, and allow the barrel to swing rearward thereon. As both links are of the same length, the rearward movement of the barrel in swinging, carries the barrel slightly downward, but the longitudinal axis remains parallel to its previous direction.

Below the barrel the frame has a tubular seat for the retractor spring (12), which in front is closed by a plug (13) fastened in the frame by the lower link-pin. The top surface of the frame (1) and two longitudinal grooves on its sides form the seat for the slide (3), which is capable of sliding backwards and forwards upon it. The rear part of the slide forms a bolt (3*a*), the forward extension of which is a partially tubular cover enclosing the barrel.

In the forward part of the frame is a transverse mortise

extending through the retractor spring seat, and transverse recesses in the forward part of the slide serve to admit the slide lock (14), which, passing through the sides of the slide and through the mortise, serves to lock the slide to the frame. The retractor spring in its seat in the frame consists of a spiral spring, the rear end of which rests against a short stiff recoil spring (15), and the front end of the retractor spring carries a follower (16).

The rear face of the slide lock (14) has a slight recess, and when this lock is in its place, the front end of the follower (16) rests in this recess, thereby confining the slide lock laterally; thus the tension of the retractor spring is exerted to force the slide to its forward position, while the recoil spring (15) serves to receive any excess of recoil of the slide.

Upon the barrel are three transverse ribs (2*a*), and in the interior of the slide are three corresponding recesses. These serve to lock the barrel and the slide firmly together when in their forward or closed position.

Between the locking recesses and front of the bolt the slide has an opening on the right side for the ejection of the empty cases. The bolt is provided with an extractor (17), a firing pin (18) and a firing pin spring (19).

The magazine (4) is a sheet steel holder in which the cartridges are placed one above the other resting upon a platform (20) acted on by a spring (21) which presses upward. The upper end of the magazine is open to permit the escape of the cartridges; the side walls at the rear of the opening are turned inward and engage the rim of the topmost cartridge to prevent its escape from the magazine until it is pushed forward.

Action of the mechanism.

The magazine can by loaded with any number of cartridges from one to seven. The charged magazine is inserted in the handle, the slide is drawn once to the rear by hand.

This movement cocks the hammer, and when the slide is in this position the magazine platform and spring raise the topmost cartridge so as to bring it into the path of the bolt; the slide on being released is carried forward by the retractor spring, and during this movement, the bolt places the cartridge in the chamber. As the slide approaches its forward position the front of the bolt encounters the rear end of the barrel and forces the barrel forward. During this forward movement the barrel also swings upward on the links (10 and 11), and thus the locking ribs (2*a*) on the barrel are carried into the locking recesses in the slide; the barrel and slide are thereby positively interlocked and the pistol is ready for firing.

The pull on the trigger now serves to move the sear (7) so as to release the hammer (6) and fire a shot. The force of the powder gases driving the bullet from the barrel is rearwardly exerted against the bolt (3*a*), overcoming the inertia of the slide and the tension of the retractor spring, and as a result the slide and the barrel recoil together. After moving rear-

ward together for a distance, enough to ensure the bullet having passed from the barrel, the downward swinging movement of the barrel releases the latter from the slide, leaving the barrel in its rearmost position. The momentum of the slide causes the latter to continue its rearward movement, thereby cocking the hammer and compressing the retractor spring until, as the slide arrives at its rearmost position, the empty case is ejected from the side of the pistol and another cartridge is raised in front of the bolt. During the return or forward movement of the slide, caused by the retractor spring, the cartridge is placed in the chamber, the slide and barrel are interlocked, thus making the pistol ready for another shot.

It is impossible for the firing pin to discharge or even touch the primer except under the full blow of the hammer.

The pistol is also provided with a safety device which makes it impossible to release the hammer unless the slide and barrel are in their forward position and safely interlocked; this safety device also serves to control the firing and to prevent more than one shot from being fired for each pull of the trigger. It consists of a small vertical piece mounted in front of the sear in the receiver, the end of which slightly projects from the top of the receiver; in its raised position, when the bolt and slide are in the forward position interlocked with the barrel, it finds a corresponding recess in the bottom of the bolt. In this raised position, the safety piece does not interfere with the operation of the trigger, but when the slide is moved rearward the bottom of the bolt depresses the safety piece which, in that position, prevents the movements of the trigger from operating the sear, and thus the hammer cannot be released until the slide is again in its forward position, locked to the barrel.

This pistol is particularly well protected from sand or dirt getting into the working parts by the slide. When the pistol is closed, the opening through which the cartridges are ejected is closed by the side of the barrel.

DETAILS of the above Pistols.

——	Mauser.	Borchardt-Leuger.	Colt.
Calibre	·3 inch	·301 inch	·35 inch
Length of barrel ..	$5\frac{1}{2}$ inches	4·8 inches	6 inches
Weight	2 lbs. $7\frac{1}{4}$ ozs.	1 lb. 13 ozs.	2 lbs. 4 ozs.
Magazine contains ..	10 cartridges	8 cartridges	7 cartridges
Weight of bullet ..	85 grains	92·6 grains	105 grains
Muzzle velocity ..	1400 f.s.	1150 f.s.	1300 f.s.

Another type of Browning pistol, differing from that manufactured by the Colt Company, in that it is ·301 bore and belongs to Class II, firing a very light charge, has been adopted for use by the Belgian army and police.

The advantages of automatic pistols, as compared with revolvers, are:—

1. Rapidity of fire, for as long as there are cartridges in the magazine, all the firer has to do is to press the trigger. This advantage is also shared by an automatic revolver.

2. Rapidity of recharging. The magazine can be exchanged, or refilled by means of a charger, more quickly than the chambers of a revolver can be reloaded, cartridge by cartridge. The Webley clip loader for automatic revolvers may get over this disadvantage, if experience proves that it is sufficiently durable for service. It must be remembered, however, that revolvers or pistols will but rarely be required to be recharged in a hurry in action.

3. Automatic pistols generally carry a greater number of cartridges than revolvers.

4. There is no escape of gas between chamber and barrel as there is in a revolver, excepting those of the Nagant type. This escape of gas lowers the velocity, and corrodes the adjacent parts.

5. The shock of recoil is reduced, as the recoil is communicated to the hand through the medium of springs, so that the recoil partakes more of the nature of a push than a blow. A higher velocity can be employed in an automatic pistol than in a revolver, without inconvenience from excessive recoil.

6. Automatic pistols are generally narrower and more compact than revolvers; this is particularly the case with the Browning or Colt automatic pistol.

Disadvantages of automatic pistols:—

1. They are necessarily more complicated, as the mechanism has to perform the operations of extraction, reloading, and cocking, which in a revolver are performed by hand.

2. Uncertainty of action; this is due to the fact that the working of the pistol depends on the recoil. This may be affected by numerous variables in the cartridge; also the automatic working of the moving parts depends upon the state of cleanliness and lubrication of the pistol.

Automatic pistols and revolvers are intended for personal defence at short range, therefore certainty of action is essential, as there is usually no time to rectify a jam, however slight. Before a revolver is superseded by an automatic pistol it is most desirable that the latter should be as certain in its action under service conditions as is the former.

Some makes of automatic pistols are sighted up to 1,000 yards, and are provided with attachable butts. This does not appear very desirable from a military point of view, as the pistol, even when used with the butt, is very inferior in accuracy to a carbine. The sighting differs considerably when used with and without a butt.

As the *rôle* of a pistol is for use at short range, the bullet should inflict a paralysing wound, particularly in savage warfare, therefore a heavy bullet of large diameter, with a

moderate muzzle velocity, is preferable to a small one with a high muzzle velocity. The tendency with most of the automatic pistols has been to reduce the bore to about ·3 inch, and increase the muzzle velocity, on the lines of the modern small bore rifles. With rifles this course was necessary to obtain a flat trajectory without excessive recoil. With weapons for personal defence at short range, such as automatic pistols, or revolvers, these advantages are of minor importance compared with wounding power.

There is now a tendency, on the part of countries employing small calibre pistols, to return to the large bore type, and, from present experience, it would seem that ·4 inch is the minimum limit of calibre for an efficient pistol, and even so, if this limit is at all closely approached, care must be taken to provide a sufficiently high velocity, and a sufficiently thin envelope for the bullet.

The method of recharging automatic pistols by means of a spare magazine is decidedly preferable to recharging the magazine by means of a charger; for with the latter method there is more liability of a jam, and it is less rapid, although in the hands of an expert, under favourable conditions, a high rate of fire has been attained when using chargers. Chargers have been made for automatic pistols with a sliding thumb-piece; these are a decided improvement on the ordinary charger, as they are much less likely to cause a jam when filling the magazine. The alleged disadvantages of spare magazines are their extra cost and weight. These would be of importance if all pistol cartridges were kept packed in spare magazines; but it would be only necessary to issue two spare magazines with each pistol, and carry the reserve cartridges in packets, to be loaded into the spare magazines as opportunity occurs; for the situation is hardly conceivable where a man would require to fire away more than three magazines full of cartridges at pistol range without an opportunity occurring for refilling them.

In comparing the advantages of a hammer, such as is used in the Mauser and Colt, with a striker, operated by a spiral spring within the breech bolt, as is employed in the Borchardt-Luger, the advantages appear to be in favour of the former; for in an emergency the firer can see at a glance whether his hammer is cocked or not, and, if necessary, can cock it with one hand. Again, with pistols fired by means of a striker operated by a spiral spring, the chamber cannot be kept loaded unless the mainspring is kept compressed; this, in the course of a campaign, would be liable to weaken the spring and cause miss-fires.

CHAPTER X.

Explosives.

Explosives are those substances, either solid or liquid, which, on the application of heat, or other cause setting up chemical action in them, are capable of instantaneous or extremely rapid conversion into gases, occupying a very great volume as compared with that of the original substance; the gases in addition are highly expanded by the enormous heat resulting from the chemical action accompanying the change of state.

Classification. Explosives may be divided into three classes, according to the purposes for which they are used :—

(1) *Disruptive explosives*, which are employed to produce crushing or shattering effects, as in blasting, and in the bursting charges of shells and torpedoes.

(2) *Propellants*, which are employed for imparting motion to projectiles of all kinds.

(3) *Explosives used for ignition purposes*, *i.e.*, to produce a flash that will ignite some other explosive, or to convey a flash, probably at the same time increasing its volume, from one explosive to another. This class includes the explosives in percussion caps, fuzes, detonators, &c.

A further classification is that of "explosive mixtures," and "explosive compounds." "Explosive mixtures" are those explosive substances which are merely intimate mechanical mixtures of certain ingredients, themselves usually non-explosive; gunpowder, a compound of saltpetre, charcoal and sulphur, is the chief explosive of this class. In "explosive compounds," the elements, composing the explosive, are all in direct chemical combination, presenting a definite explosive molecule; the nitro-celluloses, nitro-glycerine, the fulminates and picrates, are examples of this class. Smokeless propellants consist either of a single explosive compound submitted to suitable treatment, or of a mixture of explosive compounds with or without the addition of one or more non-explosive ingredients.

Gunpowder. Historical. The early history of gunpowder is very obscure, as is also the exact year and country in which firearms were invented. Gunpowder appears to have been first produced in England in Edward III's reign, about the year 1345; but it was not until Elizabeth's reign that its manufacture can be said to have been really established in this country. About the year 1590, one George Evelyn received the royal license to set up powder mills at Long Ditton and Godstone. The works at Faversham, afterwards for so many years the Government powder factory, also

date from Elizabeth's reign. There seems, however, reason to suppose that powder mills existed at Waltham Abbey so far back as 1561, for in that year we find John Thomworth, of Waltham, in treaty, on behalf of Queen Elizabeth, for the purchase of saltpetre, sulphur, and staves for barrels. Fuller, appointed Vicar of Waltham in 1641, refers to the powder mills at that place as having existed for years. In 1787 these works were sold to the Crown by John Walton, a relative of Isaac Walton, the celebrated angler.

The chief disadvantages attending the use of gunpowder as a propellant are the smoke and fouling resulting from its explosion, and it has now been superseded as a propellant by various smokeless explosives.

Smokeless powders, as their name implies, should produce no smoke on explosion, but this result is rarely completely attained, for reasons which will be explained later. Smokeless powders. Historical.

The history of smokeless explosives may be said to have commenced in 1846, in which year the German chemist Schönbein announced the discovery of "cotton powder" or "guncotton," which he proposed as a substitute for gunpowder as possessing the advantage over the latter of burning without any noticeable residue, and consequently without smoke.

Guncotton at once became an object of great scientific and practical interest, and nearly every European country took up the matter with the view of utilising the new explosive for war purposes, factories being established for its production on a large scale. Messrs. Hall and Son, of Faversham, commenced its manufacture in this country, but a terrible explosion which took place at their works, together with other accidents in this country and abroad, inspired so much alarm and distrust, which was increased by the impossibility of satisfactorily accounting for the accidents in the then state of knowledge of the substance, that the manufacture of guncotton, in this country and in France at all events, was given up for several years.

In Austria, General von Lenk, of the Artillery, still continued to experiment with it, and succeeded in considerably improving its manufacture and purification.

The attempts to use it as a substitute for gunpowder for military propulsive purposes had been unsuccessful, owing to the impossibility of controlling, with certainty and uniformity, its rate of combustion. No mechanical treatment could remove the porosity of guncotton, and, this being so, the heated gases, evolved when the guncotton was ignited in a confined state, eventually produced a pressure that caused them to permeate the mass of the explosive, and the desired "combustion" was converted into a "detonation," which was, of course, fatal in the bore of a gun. After extensive trials, however, General von Lenk succeeded in so altering the mechanical condition of guncotton as to modify its rate of combustion in air, and therefore, as it was then believed in Austria, to render its application for military purposes possible. In fact, its manufacture

in that country was approved, and in 1862 the Austrians armed thirty field batteries with guncotton cartridges. General von Lenk's system consisted in making guncotton from yarn and thread of various sizes and degrees of compactness, spun from long staple cotton, and then twisting and plaiting the gun-cotton yarn in various ways and winding it more or less tightly over cones or spindles of wood or paper, or weaving it into cartridges of various shapes and sizes. General von Lenk's improvements were effectual in moderating the rapidity of explosion in air, or under slight confinement, but were after all found of no practical utility when guncotton was confined in the bore of a gun, especially in considerable charges. Such a result was inevitable for the reason referred to above, but the Austrian experiments had their value as they led to the study of guncotton being resumed in England in 1863, and the result of very extensive experiments, carried out under the direction of Sir Frederick Abel, ultimately resulted in the adoption of a method of manufacture, whereby a practically complete purification was obtained, and the material was converted, by means of reduction to a very fine state of division and subsequent compression, into a thoroughly compact, homogeneous mass. In this form guncotton was introduced for torpedo and mine charges, but to develop the full explosive effect it was necessary that the charge should be strongly confined, and this much reduced its range of application.

However, all necessity for confinement ceased, when it was discovered in 1869 that compressed guncotton, either dry or wet, could be fully detonated by fulminate of mercury in a totally unconfined state.

The first application of guncotton, or rather of an analogous substance, for propulsive purposes, was in the Schultze sporting powder, patented in 1867. This powder consisted originally of nitrated wood fibre impregnated with nitrates and and chlorates, it was not entirely smokeless and was never used for military purposes.

The E.C. sporting powder, introduced in 1882, was a mixture of soluble and insoluble nitro-celluloses, mixed with metallic nitrates.

It was not until the year 1885, when the introduction of small calibre magazine rifles was beginning to occupy the attention of the principal European countries, and the use with them of a smokeless powder became an absolute necessity, that a method of treating nitrated cellulose was arrived at, which reduced the latter to a condition in which it could be employed with safety, to give regular and reliable results for military propulsive purposes. To convert it into a substance absolutely devoid of all porosity was the result to be arrived at, and this was eventually obtained by subjecting the nitrated cellulose to the action of suitable solvents, which would gelatinise it, and on evaporation leave a compact, homogeneous, non-porous material, capable only of burning from the

exterior towards the centre. The gelatinised material, before the evaporation of the solvent, could, whilst still plastic, be rolled or pressed into sheets, cords or other desired forms, and when dry, cut up into discs, tablets, cylinders, &c. On these lines many smokeless powders have been produced and are in general use. They differ in details of manufacture, and frequently contain, besides nitro-cellulose, other explosive or non-explosive ingredients.

The first smokeless military rifle powder was that invented in 1884 by the French chemist Vieille for the Lebel rifle. It was originally a mixture of nitro-cellulose and picric acid; the latter ingredient was, however, subsequently abandoned, and "Poudre B," as it is called, now consists of a gelatinised mixture of soluble and insoluble nitro-celluloses.

Nitro-glycerine was discovered in 1847 at Turin by the Italian chemist Sobrero. For many years it remained a laboratory curiosity, and it was not until about the year 1863 that the late Mr. Alfred Nobel, a Swedish engineer, commenced its manufacture on a large scale on the Continent, with a view to using it as a blasting agent. In 1867 Mr. Nobel produced "dynamite," which is a mixture of nitro-glycerine and a porous infusorial earth known as "Kieselguhr." Later on he introduced a further development by replacing the inert substance Kieselguhr, by an active explosive, namely soluble nitro-cellulose, the explosive so obtained being known as "blasting gelatine." To Mr. A. Nobel again belongs the credit of the employment of nitro-glycerine as an ingredient of an explosive for propulsive purposes, for in 1886 he made the further discovery that if the proportion of nitro-cellulose was increased until it about equalled that of the nitro-glycerine, and the materials were incorporated by malaxation or rolling between hot rollers, a horn-like product capable of being cut up or granulated into any desired form or size, and suitable for use as a propellant, resulted. Camphor was also employed by Mr. Nobel as a further agent for promoting the union of the two explosives, as well apparently as for reducing the rapidity of explosion of the product. This explosive was patented in 1888 under the name of "Ballistite," and is still employed in some countries. The camphor, however, does not remain a constant ingredient owing to its volatility, the result being alterations in the ballistic properties of the material. This is a grave defect in any explosive, especially when it has to stand exposure in the various climates it would have to encounter in the British service, and the defect was eventually recognised by Mr. Nobel, the employment of camphor being subsequently abandoned by him, but it was with a view to removing this defect, and to using guncotton instead of soluble nitro-cotton, in order to obtain an explosive of uniform composition and high ballistic qualities, that the Explosives Committee, of which Sir Frederick Abel was President, carried out a long series of exhaustive experiments. The final result

of their labours was the production of a smokeless propulsive explosive, consisting essentially of nitro-glycerine and guncotton, incorporated and gelatinised by the aid of a solvent. A small proportion of mineral jelly is incorporated in the preparation; originally introduced to prevent "metallic fouling" in the magazine rifle, experience has shown mineral jelly to operate beneficially in regulating the explosiveness of the product, and more especially in improving its uniform stability under varied climatic conditions. This smokeless explosive is known by the name of "Cordite," owing to the cord-like form it assumes in manufacture. Its percentage composition is as follows :—

Cordite.

	Per cent.
Nitro-glycerine	58
Guncotton	37
Mineral jelly	5

This explosive has proved, after years of use, to be satisfactory in its stability, both chemically and ballistically. Its main defect is the erosion it produces, particularly in heavy ordnance, owing chiefly to the great heat it develops. The principal heat-producing factor in the compound is the nitro-glycerine, and for this reason a rearrangement of the proportions of guncotton and nitro-glycerine was approved on the recommendation of Lord Rayleigh's Explosives Committee, and Cordite M.D., (modified cordite), has the following proportions :—

	Per cent.
Nitro-glycerine	30
Guncotton	65
Mineral jelly	5

Properties.

Before describing the general lines of the manufacture of smokeless powders, the principal properties which all smokeless powders should, as far as possible, combine, will be briefly referred to.

Smokelessness.—Smoke is due to the presence of solid products of combustion in a very fine state of division. Substances which, on explosion, could produce nothing but non-condensible gases would be perfectly smokeless; as, however, the explosion of practically all modern powders gives rise to vapour of water which condenses, they all show a slight amount of smoky vapour varying according to the degree of moisture in the air. This is slightly increased by the products of combustion of the small proportions of organic and inorganic matter, in most cases added as moderants. As a rule, the smoke is small in quantity and dissipates quickly.

Freedom from Objectionable Products of Combustion.—The gases given off should not be such as will injuriously affect the firer. Carbonic oxide, a poisonous gas, is produced in considerable quantity by the combustion of most smokeless powders, but as it is a combustible gas and, at the moment of

its production, highly heated, it takes fire on issuing from the barrel and burns away. Other objectionable gases, which it was thought nitro-powders might evolve, are nitrogen oxides, but these, under the ordinary conditions of firing, are not produced, or if produced are instantly destroyed again by the combined action of the large volume of reducing gases, carbonic oxide and hydrogen, and the high temperature.

The tendency of rifle and gun barrels to become rusty after firing nitro-powders was at one time ascribed to the presence of nitrogen oxide in the explosive gases, and special oils containing alkali were recommended for cleaning the barrels. It is now understood that this tendency is due to another cause, *i.e.*, the fact that the very high temperature of the gases of explosion affects the surface of the bore and renders it more susceptible to the corroding action of air and moisture.

Freedom from Erosive Effects. In the case of heavy guns the quantity of heat evolved has an important bearing on the amount of erosion, or wearing away, which takes place in the bore. It is greater with smokeless powders than with the old black powders, and greatest in the case of those of the former that contain nitro-glycerine. Although with these nitro-glycerine powders a lesser weight of charge, as compared with other smokeless propellants, is undoubtedly required for the production of the same velocities with lower chamber pressures, yet, owing to the extra heat developed, the amount of erosion is larger with the first named powders. This is also the case with small arms and machine guns, especially the latter, and has led to the more general adoption of the pure nitro-cellulose class of smokeless powders for them. By reducing, however, the quantity of nitro-glycerine, as in the case of cordite M.D., the defect is overcome.

Stability. Stability, both chemical and ballistic, under all conditions of climate, storage and use, is undoubtedly one of the most important properties of any explosive. With black powders, so long as they were kept dry, there was no question of want of stability. Now that the manufacture and proper purification of nitro-bodies are well understood, there is also no difficulty in making those used for smokeless powders very stable.

High velocities with moderate pressures. The introduction of magazine rifles and quick-firing guns necessitated, not only the employment of a powder producing little if any smoke, but also, to enable the weapons to develop their full effect, one giving much higher velocities than those obtainable with the old black powder, without exceeding the permissible limits of pressure in the bore. These improved ballistics became possible with the new powders, owing, to a great extent, to their colloidal or structureless form. Ignition having taken place on the surface of the flake, cube or cord, combustion can only proceed by successive layers, with the result that, although a much larger total volume of gas, and therefore greater velocity of the pro-

jectile is now developed than formerly, this development of gas takes place gradually during the whole time of the passage of the projectile down the bore, with correspondingly uniform distribution of pressure. The total propelling force is naturally greater than formerly, but, as it is more sustained, the maximum pressure is not correspondingly increased. It follows, therefore, that for equal velocities much smaller charges are required than was the case when black powder was used, and the chamber pressures are lower, also that for the same or even lower chamber pressures higher velocities are obtained. In the old powders, complete combustion of the explosive took place before the projectile had time to move far down the bore of the gun, high pressures were in consequence set up in the chamber necessitating a massive breech. As the development of the gas and, therefore, of the pressure fell off rapidly, the gun thinned down considerably towards the muzzle, and was comparatively short. For smokeless powders the guns are more uniform in outline to suit the more uniform distribution of pressure, and they are longer, to enable the full effects to be obtained from the comparatively slow burning explosive. It is obvious that the property of burning in successive layers affords a ready means of adapting the new explosives to the various calibres of small arms and ordnance for which they are used. By increasing the thickness of the flakes or cubes, or the diameters of the cords or cylinders, the surface of ignition for a given weight is decreased, with a corresponding decrease of initial development of gas and consequently of initial pressure, whereas the time of total combustion is increased. The thicker the flake, cube, or cord, the slower burning the powder, and the larger the gun in which it can be advantageously used.

Ease and safety of manufacture. The manufacture of smokeless powders consists in, firstly, the production of the nitro-compounds; and secondly, their treatment with suitable solvents to give them the required colloidal condition. As regards the manufacture of nitro-cellulose the operations are simple, and free from all risks, as, throughout the operations, the nitro-cellulose is always being dealt with in large volumes of water, in which condition it is quite harmless. The manufacture of nitro-glycerine is one of more difficulty and danger. It is a liquid very sensitive to friction and percussion, and, when acid, it has a great tendency to decompose spontaneously, if adequate means are not adopted for controlling the temperature while the material is in contact with acids. The precautions to be observed in its manufacture are based on these considerations.

In most processes for the production of smokeless powders, the nitro-cellulose has to be dried before further treatment. This operation must be conducted with great care, as dry nitro-celluloses, particularly guncotton, are very sensitive to friction and shock of all kinds. When once the solvent is added to the nitro-cellulose, or to the mixture of nitro-cellulose and nitro-

glycerine, the danger of accidents is much lessened, and the manufacture of smokeless powder from this point is much safer than that of the old gunpowders. In the latter case there was always present a more or less considerable amount of explosive dust which formed a highly explosive mixture with the air, ignitable by the smallest spark and liable to, in its turn, explode the dusty gunpowder in process of manufacture. In the case of smokeless powders there is practically no dust, and the explosives themselves wetted with the solvent and more or less gelatinised, if ignited, would burn away very fiercely but without explosion unless confined; and even if confined, as in the press cylinders, an ignition or explosion would be entirely local, and would not spread to the bulk of the material under treatment.

Physical properties. Most service, small arm, smokeless powders are in the form of flakes, cubes, cords, or cylinders either solid or tubular; sporting powders are required to be quicker burning, and are often granular like the old gunpowders, or in the form of very thin flakes. The colours vary considerably, and depend to a great extent on the added non-explosive ingredients. Pure nitro-cellulose powders are, as a rule, greyish or yellow; those in which nitro-glycerine is present, vary in colour from light yellow to deep brown. Sporting powders sometimes contain colouring matter, and are frequently coated with graphite, which gives them a silvery grey appearance. The surface of the flake, cube, and cord powders is usually smooth and hard, and in texture they are horn-like if made from nitro-cellulose, but softer and more of the consistency of indiarubber if containing nitro-glycerine. Their density varies according to the ingredients and method of manufacture. Unless they contain ingredients soluble in water, such as metallic nitrates, they are unaffected by damp, and they do not absorb any appreciable amount of moisture. They are more difficult to ignite than black powders, and, in the case of small arm powders, require a stronger cap.

Experiments, carried out with cordite on several occasions, have shown that, when packed in the service stout wood boxes with screwed down lids, the boxes may be subjected to a fierce fire which will only ignite the cordite without explosion when the flames reach it, and that the cordite in a box may be ignited and burnt away without exploding, or even setting fire to, boxes packed round it. As far as experiments have hitherto shown, most smokeless powders are fairly insensitive to shock and are not exploded by the impact or passage through them of rifle bullets, even when made up in small arm cartridges packed in boxes.

Manufacture.

The manufacture of practically all natures of smokeless powders is generally conducted on the same lines, the principal operations being as follows:—

(1) Incorporation and gelatinisation of the ingredients, by means of a solvent, or by heat and pressure.

(2) Conversion of the gelatinised material into the desired form, by pressure, &c.

(3) Elimination of the solvent.

Incorporation.

(1) For the first operation, a kneading machine is usually employed. It consists essentially of an iron box on suitable supports, open at the top, and provided with a removable cover, the bottom being shaped to form two semi-circular troughs, in each of which a spindle, with propeller-shaped blades, revolves. The spindles turn in opposite directions, one moving at twice the speed of the other. The blades revolve in close proximity to the bottom of the machine and the material is continuously being squeezed between the blades and the bottom, and between the blades themselves as they approach each other along the centre line. The action is, in fact, a kneading one, and the machine is very similar to those used for making biscuit dough, and for many other like purposes.

The nitro-cellulose and any other ingredients are thoroughly dried as a preliminary step; if nitro-glycerine is to be used it is settled as free from water as possible. The dried nitro-cellulose is loaded into the incorporator which, as a rule, contains a portion at least of the solvent, or a portion of the solvent may be roughly mixed with the nitro-cellulose before it is put into the machine. The other ingredients if any, are added, in a finely powdered condition if solid, either directly after the nitro-cellulose or at some suitable period during the incorporation; if liquid, or if soluble in the solvent employed, they may be added with the latter. Nitro-glycerine is usually mixed roughly with the nitro-cellulose before charging into the incorporating machine, or it may be mixed with some of the solvent and added in this condition.

The time of incorporation varies with the different compositions and the quantity of solvent employed, and may last from four to eight hours. It is complete when the charge is of a uniform consistency, and shows none of the distinctive characteristics of any of its ingredients such as, for instance, the fibre of nitro-cellulose. In this condition it is usually of a dough-like consistency.

In the manufacture of Ballistite, which is a mixture of soluble nitro-cellulose and nitro-glycerine, the gelatinisation in the incorporating machine by means of a solvent is usually dispensed with, because nitro-glycerine has the property of itself gelatinising soluble nitro-cellulose when a mixture of the two is subjected to heat and pressure between rollers, as described below. Another modification is that of dispensing with the drying of the nitro-cellulose. The nitro-glycerine is added to the nitro-cellulose, suspended in a large bulk of water, and the whole thoroughly mixed by means of jets of compressed air. The nitro-glycerine displaces the water, the bulk of which is drained off first, and the remainder almost entirely eliminated by submitting the mixture to moderate pressure, the mixture is then passed through hot rollers, which treatment removes the

last traces of water at the same time as it effects the gelatinisation.

In the manufacture of some nitro-cellulose powders, notably in Austria, the nitro-cellulose is dehydrated by means of alcohol, which replaces the water and is itself either driven off by heat, or is retained in the nitro-cellulose, which is usually of the soluble variety, and thus forms part of the gelatinising medium.

(2) In the case of flake or cube powders the pressing operation differs somewhat from that employed for cords or tubes and is usually combined with the operation of removing the solvents and moisture. When the finished explosive is to be in the flake or cube form, the dough or paste is taken from the incorporating machines, whilst in a plastic condition, and rolled out into flat sheets between adjustable, horizontally placed, chilled, cast-iron rolls, which are hollow and are usually steam heated. The sheets are next placed in a drying stove where the solvent is driven off by heat. After drying, the sheets are again passed between heated rollers, placed vertically as a rule, to remove irregularities and blisters formed during the previous drying. In the final rolls the material is given the required thickness by folding the thin sheets over and over, and passing them backwards and forwards through the hot rolls. In these operations the sheets are so thoroughly welded together that, when cut through vertically, no dividing lines can be detected. The sheets, when finished rolled, are first of all cut into strips, and then the strips cut into flakes or cubes according to the thickness of the original sheet. The finished powder is finally dried, to expel as far as possible the last traces of the solvents and moisture. A temperature of about 40° C. is usually employed. The flake small arm powders are usually blackleaded, mainly with a view to their running freely in the cartridge loading machines. **Pressing.**

To produce a cord or tube powder, the incorporated material is transferred, with as little loss of solvent as possible, to the cylinder of the pressing machine. This cylinder, secured in a suitable frame work, is open at the top and closed at the bottom by a removable plug, having one or more holes or dies in it of the size and shape to produce the finished form required. If tubes are to be produced pins are arranged so as to project into the holes of the dies. A plunger, actuated either by means or a screw and suitable gearing, or by hydraulic pressure, is made to enter the open end of the cylinder and, in descending slowly, it forces the material in a continuous thread or tube out through the dies. The cord or tube, as it leaves the die, is cut at once to the length required and packed on wooden or other natures of shallow trays, or it is reeled on drums, usually of metal, without being cut.

(3) The removal of the solvents and moisture, in the case of cords or tubes, is a distinct process, following the production of the material in its finished form. The trays or reels, containing **Drying.**

the explosive, are arranged in a drying stove, where the solvents and moisture are expelled at a temperature of about 40° C., the length of time, required for this, depending on the diameter of the material. In the case of nitro-glycerine powders the drying can be more completely effected than in the case of the nitro-cellulose ones; the greater also the proportion of nitro-glycerine, the quicker and the more thoroughly is the drying effected.

To ensure uniformity in ballistics of the finished explosive, blending of different batches is resorted to.

Classification. The smokeless powders in use for military small arm cartridges are conveniently classified under two main heads:—

(1) Those composed of nitro-cellulose, either alone or with small quantities of other explosive or non-explosive ingredients.

(2) Those containing nitro-glycerine, in various proportions, as a further ingredient.

The military small arm powders of Class I are those of Argentine, Austria, Belgium, Brazil, Bulgaria, China, Columbia, Denmark, France, Germany, Holland, Japan, Mexico, Portugal, Roumania, Russia, Servia, Spain, Switzerland, Turkey, United States, Uruguay.

To Class II belong the powders of Great Britain, Italy, and Norway.

Further particulars are given in Table IV, Appendix.

CHAPTER XI.

Small-Arm Ammunition, Chargers and Clips.

In the earlier stages of firearms, the bullet and the powder were carried separately. At the commencement of the 17th century, Gustavus Adolphus, King of Sweden, caused the gunpowder, which had hitherto been carried in flasks or bandoliers, to be made up into cartridges and carried in pouches. The packing together of each bullet and its charge of powder to form a complete cartridge, containing also its own means of ignition, followed shortly after the discovery at the early part of the 19th century, of the percussion cap. This form of cartridge was peculiarly suited to the breech-loading system, and was first introduced by Dreyse for the original breech-loading needle-gun of Prussia. The bullet of his cartridge was egg-shaped, the base fitting into a shoe or wad of compressed paper, which carried the percussion cap in the opposite side. The wad being of larger diameter than the bullet imparted rotation to it, but was weakened so as to fall to pieces on leaving the muzzle. The powder charge, bullet, and wad were made up in a case of rolled paper, closed in rear, and tied up over the point of the bullet. The needle pierced the base of the paper cartridge, and, passing through the powder, ignited the cap. In the cartridge for the French Chassepôt of 1866, there was no cup-shaped wad, the cap being secured to a disc of cardboard at the base of the paper cartridge case, another disc carrying a grease wad, was placed behind the bullet. The bullet itself was surrounded by greased paper, which did not cover the point, but extended about half-way down on the exterior of the paper case, and was tied to it. The cartridges for the Swedish and Russian rifles, patterns 1867, and the Italian rifle, pattern 1868, were of similar construction.

Paper cartridges, however, were found not to be self-consuming, as was expected, neither did they stand satisfactorily the rough usage of service, nor, which was of more importance still, did they effect the obturation of the breech, the escape of gas to the rear being provided against in the rifles in which they were used, by the special construction of the breech mechanism.

The desirability of sealing the breech, by means of the cartridge case itself, had long been recognised, and it was in this country that this principle first received practical application to military small arms, by the invention of Colonel Boxer in 1865, for the Enfield muzzle loading rifle converted

to a breech loader on the Snider principle, of the coiled metal built-up, central-fire, cartridge which originally bore his name.

The Boxer cartridge, or, as it is now called, the "rolled case" cartridge, was approved for use with the Martini-Henry rifle, when that arm was definitely adopted in 1871. See Plate LVIII.

Our original example was quickly followed by other nations, and the general introduction of breech loading arms was accompanied by that of metallic cartridges; the cases, however, instead of being built-up ones of coiled brass with iron base disc and separate cap chamber, were generally made of copper or brass drawn out solid from a round disc, the cap chamber being raised out of the solid metal of the base disc itself.

Solid drawn cartridge cases, which are stronger and which keep their shape better when subjected to the rough usage of active service, were not introduced in this country, except for machine guns, for which they are a necessity, until after the Egyptian campaign of 1885, when, owing to the complaints which were made that the rolled case cartridge would not extract readily after firing, a supply of solid drawn cartridges for the Martini-Henry arms was made for foreign and active service. The rolled case cartridge, however, being cheaper, was still manufactured for range practice.

On the introduction of the ·303 magazine rifle, solid drawn cartridges only were made for use with it.

However perfect in every respect a rifle may be, it will not shoot accurately unless the greatest care is taken to design a suitable cartridge for use with it, and to manufacture the cartridges accurately. So far as the accuracy of the shooting is concerned, the cartridge is quite as important as the rifle.

The modern military cartridge is expected to make accurate shooting and to impart a high muzzle velocity to the bullet so as to obtain a flat trajectory, and sufficient wounding power. The bullet should retain as much as possible its velocity and accuracy at long ranges, the maximum pressure should be well within the amount the rifle can withstand, and the cartridge should be durable and keep well.

The construction of the cartridge may be conveniently considered under the following headings:—

1. The bullet.
2. Wads.
3. Lubrication of the bullet.
4. The charge of propellant.
5. The cap.
6. The cartridge case.

The bullet.

In selecting a metal for bullets, there are several conditions to be observed: 1st, the metal should be as non-elastic as possible; 2nd, it should be sufficiently malleable so that perfect

expansion may be obtained by the action of the explosive; 3rd, it should be of sufficient hardness so that its form should not be destroyed by the action of the explosive, and that it may destroy animal life; 4th, the metal should be of the greatest density possible; 5th, it should be of moderate cost.

Lead, which is a very common metal and easily obtained, is one of the most inelastic substances with which we are acquainted; it requires the least force of all the metals to perfect its expansion, and it makes but little effort to resume its former shape after it has been altered by any force impressed upon it. The mixture of any other metal with lead will affect its property of non-elasticity.

In using a hardening material in combination with lead, care should be taken to use no more of it than is necessary to attain the required object, in order to retain as much density and expanding power as possible. By hardening lead its penetrating power in one sense is increased, but its density and power of expansion is diminished.

With the Snider rifle pure lead was used to ensure the bullet, which was smaller than the bore, being set up into the rifling.

The Martini-Henry bullet was composed of one part of tin to twelve of lead, for the great expansion required by the Snider bullet was not needed, as there was a higher maximum pressure and a greater length of bullet to effect the "setting up" or expansion of the bullet in the rifling. On account of this higher pressure it was necessary to give the bullet a greater power of resisting deformation. The Snider bullet was 1·8 calibres and the Martini-Henry bullet 2·8 calibres in length; both weighed 480 grains.

The cylindrical portion of these bullets was papered with thin greased paper to prevent the grooves and surface of the bore from becoming "leaded"; but if there was much fouling in the bore, it was certain after a time to become leaded even though the bullets were papered.

The old lead bullet was no longer suitable for the high velocity, and rapid rotation, which it is necessary to impart to the long, light bullet of modern weapons—the length approaching closely, and sometimes even exceeding 4 calibres—to ensure its stability in its passage through the air. Such a bullet, if made of lead, would "strip," or be driven out of the barrel across the lands without following the grooves, and it would also be partially fused by the heat developed, partly by the smokeless powders now in use, and partly by the friction due to the high velocity. The bullet therefore employed in the small calibre magazine rifles of the present day is a composite one, consisting of a core, either of soft lead or more generally of lead hardened with antimony, and a casing or envelope of some harder metal, soft steel or iron, or an alloy of copper and nickel being usually employed. The core is

inserted from the rear end of the envelope, which is afterwards turned in over the base of the core; the envelope itself is solid drawn and consequently has a solid point somewhat thicker than the sides.

The bullets are, as a rule, made with a diameter equal to that of the rifling across the lands (that is to say, the nominal calibre of the rifle) plus about the depth of one groove; in some instances even, this is exceeded, the diameter of our bullet, for example, is the diameter of the bore across the lands, plus the depth of $1\frac{1}{2}$ grooves. The result of this is, therefore, that the lands cut into the bullet, besides the bullet itself expanding on the shock of discharge into the grooves. This squeezing of the bullet into the rifling is called "engraving"; it is carried out gradually by the "lead" or conical funnel which leads from the end of the chamber of the rifle into the bore. If the bore were to end abruptly at the commencement of the chamber, the sharp ends of the lands would cut strips out of the envelope of the bullet, and the latter would fly to pieces as it left the muzzle.

In Table IV, Appendix, the material used by the different Powers for the envelopes of their rifle bullets is stated. It will be seen that cupro-nickel is the favourite. Germany, Greece, Holland, and Turkey use steel envelopes coated with cupro-nickel, Austria uses greased steel, and Japan copper envelopes. Bullets with cupro-nickel on the surface are apt occasionally to set up metallic fouling; this latter consists of a minute deposit of metal in the form of fine streaks on the lands and in the grooves of the rifle. Bullets with greased steel envelopes do not appear to possess this failing to any marked degree; but they wear away the bore more rapidly than cupro-nickel envelopes. The disadvantages of metallic fouling are that it may impair the velocity and accuracy of the bullet. When it occurs it is usually to be found near the muzzle, and is more pronounced if the charge is increased in order to give a large increase to the velocity of the bullet. It is more likely to occur when a large number of rounds are fired from the rifle without cleaning. Where the bore of a rifle has been allowed to become rough from want of cleaning it is naturally more liable to pick up metallic fouling. The best way to remove the fouling is to use a double pull-through with the wire gauze packed so as to fit the bore very tightly, taking care not to rub the breech or muzzle with the cord of the pull-through. It may also be removed by means of a preparation known as "K.N.S.," which dissolves it out.

The bullet of the Swiss cartridge is of peculiar construction. The body is of hard lead, with an envelope of nickel-plated steel over the point only; the remainder of the bullet is covered with paper lubricated with vaseline. The lower portion of the bullet entering the cartridge case is reduced in diameter. The wounding power of this bullet is very great, though the velocity of the Swiss rifle is low compared with other military rifles.

Pointed bullets are being introduced by the Powers, because a sharp head offers less resistance to the air than a rounded head, so the bullet maintains its velocity better and the trajectory is flatter. In order to further flatten the trajectory at moderate ranges, which are of greater military importance than the extreme ranges, the bullets are made lighter, which allows of a higher muzzle velocity.

To further reduce the resistance of the air, the French have slightly tapered the rear part of their bullet. This also reduces the vacuum formed at the base of a bullet when in flight. It is undesirable to entirely get rid of this vacuum, as it acts as a drag on the base, like the feathers on an arrow, and helps to steady the bullet. The disadvantage of a taper base is the difficulty of ensuring that the bullet is truly centred while it is being driven into the "lead" of the bore, especially when the "lead" is worn. The French bullet (Balle D) is solid, and is made of a copper-zinc alloy. This prevents the taper base setting up and becoming cylindrical on firing.

Light pointed bullets have now been adopted by Germany, United States, Austria, Spain and Portugal.

Bullets have also been designed with a view to piercing field artillery shields. They consist of a cupro-nickel or soft steel envelope, thicker at the head than at the sides. A hard steel core fills the head and extends $\frac{3}{4}$ of the length of the bullet, while round the sides of the core and at the back the envelope is filled with lead. The lead permits the envelope to be pressed inwards by the rifling, and allows the rear part of the bullet to set up and seal the bore. Such a bullet is effective for the object for which it is designed, but would lack wounding power.

Wads. Most cartridges for large bore military rifles had wads of some kind between the powder charge and the base of the bullet. The use of these wads was to prevent any of the powder gas escaping round the bullet on the ignition of the charge, and before the bullet has set up into the grooves, and with the old rifles which fired lead bullets and black powder the wads partially cleared the bore of fouling. In the Martini-Henry cartridge there was a glazed board wad over the powder, then a beeswax wad, then two more glazed board wads. It used to be generally supposed that wads of wax or grease lubricated the interior surface of the barrel, and were gradually expended as they passed up the bore by being smeared on its surface. This is not the case, however, with the Martini-Henry, for if some of the wads fired from this rifle be picked up they will be found to be of the same weight as similar wads taken from unfired cartridges. Although wax wads are not generally employed with smokeless explosives, a thin wad of cardboard or similar material is sometimes inserted between the explosive and the bullet, to increase accuracy and reduce wear by preventing the escape of gas past the bullet before it has been fully driven into the rifling. With cordite cartridges a wad is

employed for this reason, but with most small-bore cartridges, with granular powders, there is no wad, the bore being sealed by the bullet before any great escape of gas has taken place.

Lubrication. With the old lead bullets lubrication was effected by some substance such as grease, wax, or a mixture of them, which is either smeared on the paper round the bullet, or in the case of a naked bullet, fills one or more cannelures in the cylindrical portion. Wax is a better lubricant than grease, as the latter melts at a low temperature, and corrodes lead when in contact with it.

Lubrication was considered of advantage with a view to preventing the fouling from the black powder from taking a firm hold on the surface of the bore, and so rendering its removal easier.

The smokeless powders now in use do not deposit a layer of fouling in the bore, therefore a lubricating wad is no longer used. Cartridges, however, which are made up in chargers or clips, which are then packed in twos or threes in cardboard boxes for issue, generally have the bullets covered with some grease or oily lubricant, especially when the envelopes are made of soft steel or iron. This lubricant serves the double purpose of protecting the metal of the envelope from oxidation, and of depositing a film on the surface of the barrel, thereby preventing the contact of two clean metals and the consequent liability of a metallic deposit from the envelope, in the bore. External lubrication of the bullet not being permissible in our service, a cannelure is made near the base, this is filled with beeswax, and that portion of the bullet which enters the mouth of the case is beeswaxed also, making a practically watertight joint.

The charge. The ideal action of an explosive in a rifle is that the maximum pressure should be low, and after the maximum pressure has been reached it should be maintained up to the moment the bullet leaves the muzzle, the charge of explosive being completely consumed at the same moment, so that none is blown out after the bullet and wasted.

Such an action has never been attained, as the explosive cannot in practice be made to provide a continuous supply of gas exactly sufficient to maintain the maximum pressure in the growing space behind the rapidly moving bullet, and for other reasons which need not be discussed here.

The factors which govern the rise of pressure with any given explosive are as follows :—

(1) The density of loading, or space occupied by the charge behind the bullet.

(2) The method of ignition.

(3) The form and nature of the explosive as affecting its rate of ignition and burning.

(4) The initial resistance to motion offered by the bullet.

(1) This will be fully dealt with in Chapter II, Part II, Internal Ballistics.

(2) Modern nitro-powders are much more difficult to light than the old black powders, and irregularity of ignition is very common with them. This is due to their surfaces being usually hard and horny, owing to the gelatinising process generally employed in manufacture. Such irregularity, owing to the extreme regularity and comparative slowness with which the nitro-explosives burn, when once they are lit, results in irregular rise of pressure and disappointing ballistics.

(3) This is dealt with in the chapter on Internal Ballistics. It is sufficient here to state that horny, smokeless explosives burn only at their surface. Hence, by regulating the amount of surface that a given weight of explosive possesses, the rate of burning can be regulated. If the explosive be in large grains or cords it obviously has a smaller surface for ignition and burning than the same weight of explosive disposed in smaller cords or grains, and therefore will burn more slowly than the latter.

(4) The initial resistance to motion offered by the bullet:—

Immediately the bullet moves the space occupied by the gases of combustion increases, and the pressure tends to fall. The resistance offered by the bullet must be sufficient to cause the complete ignition of the charge, *i.e.*, the flame should get well round the sticks or grains, and burning should commence evenly all over the charge, otherwise much of the latter is blown out of the barrel unconsumed. This is due to the difficulty of ignition, and slow burning, referred to in (2). Further, the resistance must be regular, to ensure regular ignition and ballistics.

This necessity for considerable initial resistance being required to render explosion (*i.e.*, rapid burning) a certainty, i the cause of the complications with the smokeless blank cartridge for the ·303 rifle.

A *safe* nitro-explosive, however finely powdered or divided, cannot be depended on to explode, except under pressure. The word "safe" implies that the powder will, in no ordinary circumstances detonate.

It is quite easy to get ordinary (*i.e.*, ungelatinised) guncotton to explode, when simply ignited, without any initial pressure. Unfortunately, however, it will occasionally detonate, instead of simply exploding.

In the ideal cartridge therefore:—

The density of loading will be kept low;

The cap will be powerful and regular;

The charge of explosive will be regular in weight and slow burning, so as to reduce chamber pressures and let the maximum of work be done, all along the barrel, up to the muzzle but so shaped that it will ignite and burn regularly, and be completely consumed within the barrel.

The bullet will vary but little in its shape or diameter, or in the hardness of the metal constituting its envelope and core, it

will have the smallest variation in weight, compatible with reasonably simple manufacture.

Practically the cartridge is always a compromise. To reduce bulk and weight, which vitally affect the number of cartridges which can be conveniently carried either for, or by the soldier, the size is kept down, and the density of loading is correspondingly kept up. The adoption of a light pointed bullet appreciably increases the number of rounds per man that can be carried.

The cap. The cap composition in use with cordite varies somewhat from that with black powder. The proportions of fulminate of mercury and chlorate of potash are reduced, whilst some mealed powder and sulphur are added with the object of producing a more powerful and slower flame, which is necessary owing to cordite being less rapidly ignited than black powder.*

Cartridge cases. The cartridge case must combine the qualities of strength and lightness, and be of such a form as to render the operation of extracting the empty case from the chamber of the rifle as easy as possible.

Brass is the alloy which has generally been selected as the most suitable material from which to form the cases, for it is comparatively cheap, and possesses to a greater degree than any other alloy, or pure metal, the necessary properties of being light, ductile, and elastic. In ordinary circumstances also it does not corrode or otherwise deteriorate.

To economise space in the magazine the cartridges are always bottle shaped, otherwise their length, if their maximum diameter were kept the same as the bullet, would be inconveniently great. Several of the foreign cartridges have no base rims; a groove for the extractor being cut in the solid head of the case. This allows of the cartridges packing closely side by side in the charger, and prevents any jam occurring through the rim of one cartridge in the magazine getting in front of the rim of the cartridge next above it. With these cartridges there is no rim to form a definite stop to prevent the case from entering too far into the chamber; when a miss-fire, or a difficulty in extraction, or possibly even a circumferential separation, due to want of proper support by the face of the bolt might result. These rimless cartridges, however, generally have a pronounced shoulder which serves as a stop.

The Japanese cartridge case, which is semi-rimless, combines the advantages of the two systems.

The bullets are fastened into the cartridge cases by the mouth of the case being swaged on to the bullet, or by the case being stabbed into a cannelure in the bullet.

Chargers and clips. Cartridges are carried in chargers and clips (see Plates LXI to LXV) in order to accelerate the rapid loading of the

* The latest cap composition is composed of sulphide of antimony, chlorate of potash, fulminate of mercury, sulphur, and mealed powder.

magazine. Chargers are used by being placed in grooves in the body over the magazine, when the cartridges are swept out of them by the thumb into the magazine, and the empty charger thrown away.

Clips with their cartridges are placed in the magazine, the clip being held down by a catch, vide Plate V of the Austrian Rifle Pattern 1888/90. The cartridges are fed up by the magazine lever, or platform, which is made sufficiently narrow to pass between the sides of the clip. When the cartridges are expended, the clip falls out through an opening in the bottom of the magazine.

Chargers are usually made of steel; when used with rimless cartridges, their sides do not extend much past the extractor groove round the base of the cartridge. In this type of charger (known as the Mauser charger) a thin undulating flat spring presses the cartridges forward, so that the extractor grooves bear firmly against the ribs, on each side of the charger, which act as guides to the extractor grooves (see Plates LXI to LXIII of the Belgian, German, Japanese and Spanish chargers).

Rim cartridges require more support to prevent them getting askew, while being pressed down into the magazine, hence the sides of the Russian and the English chargers extend further along the cartridges, and keep them in line by lateral pressure.

The Swiss charger consists of a millboard receptacle which is open at the bottom. The bottom edges of the sides and ends are formed of tin; they are provided with four flaps, which project inwards and retain the cartridges. A broad groove for the thumb is cut partly down the left side, and completely down the right, to enable the cartridges to be swept into the magazine, the above-mentioned flaps being forced open in the operation.

All the above chargers contain five cartridges except the Swiss, which holds six, with a greater number of cartridges a jam would be more likely to occur on sweeping the cartridges out of the charger into the magazine.

The Dutch and Roumanian clips (see Plates LXIV and LXV) are very similar. Their backs are slightly curved on account of the rims of the cartridges being so much broader than the shoulders. The sides of the clips at each end are slightly turned inwards, to retain the cartridges; and indentations in the sides form a guide for the rims, except at each end, so as to allow of the bolt pushing the cartridges forward out of the clip.

The Italian clip, being for rimless cartridges, has a straight back, as the cartridges lie practically parallel to each other. The indentation in each side forms a rib internally, which acts as a guide for the extractor grooves of the cartridges. All the above clips can be inserted into the magazine, either end up.

The Austrian clip can only be inserted into the magazine one end up. The cartridges lie with their bullets sloping upwards, and the bases of the cartridges one behind the other. The back end of the clip forms a groove, along which the bases

of the cartridges pass. This is an earlier, and less perfect form of clip than those above described. All these clips contain five cartridges, except the Italian, which contains six.

It is important to keep the weight of the charger or clip as low as possible, for with large numbers the total weight becomes considerable. For example, with an army containing 200,000 infantry, supposing that 350 rounds per man were provided, and that each charger, when empty, weighed 194 grains, the total extra weight of the chargers would be 173 tons.

The following table gives the weights of the clips and chargers used by the various Powers, and the percentage that the weight of the clip or charger bears to the weight of the cartridges they carry:—

Country.	Weight of clip or charger.	Percentage of weight of cartridges carried.
	Grains.	Per cent.
Austria	312	13·7
Belgium	78	3·5
Germany	109	5·1
,, (S bullet)	109	5·9
Great Britain	194	9·3
Holland	176	10·4
Italy	192	9·6
Japan	133	7·6
Roumania	171	9·8
Russia..	130	7·2
Spain	147	7·9
Switzerland	295	11·6

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CARTRIDGES.

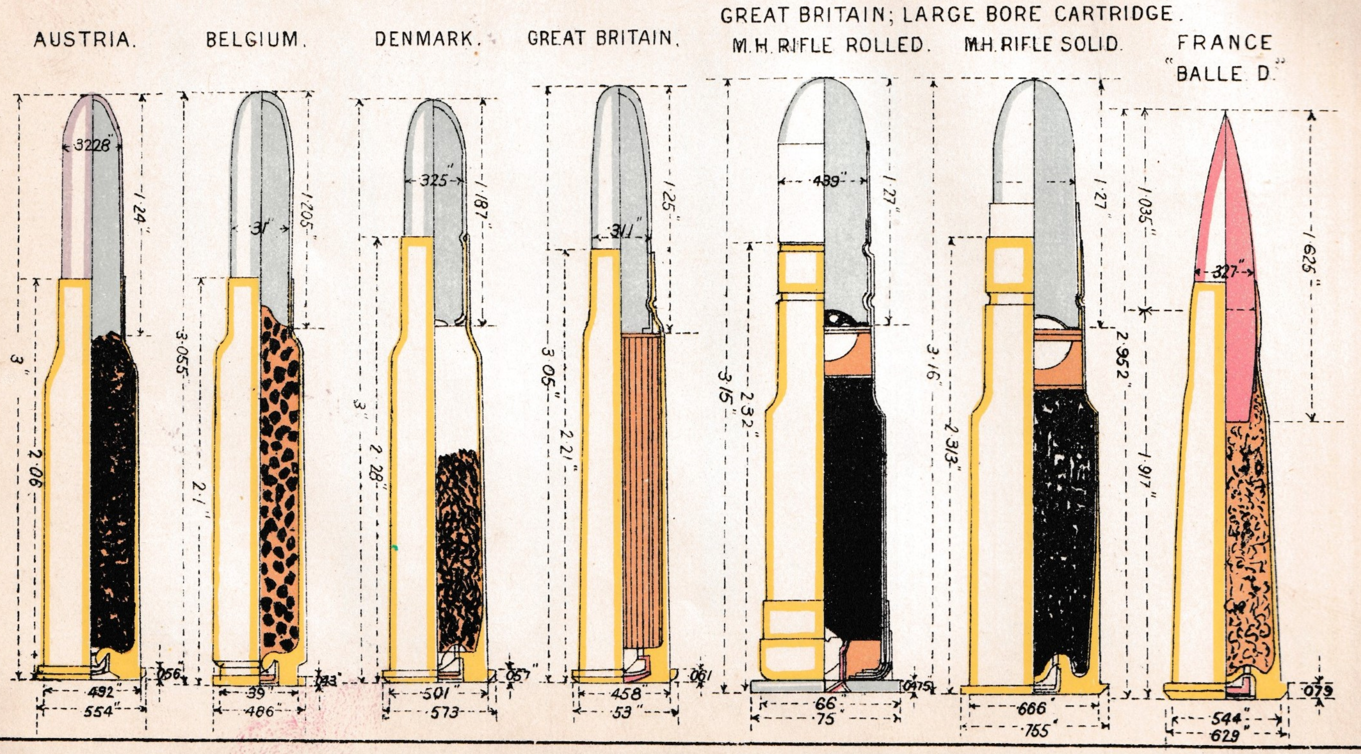

Plate LVIII

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CARTRIDGES

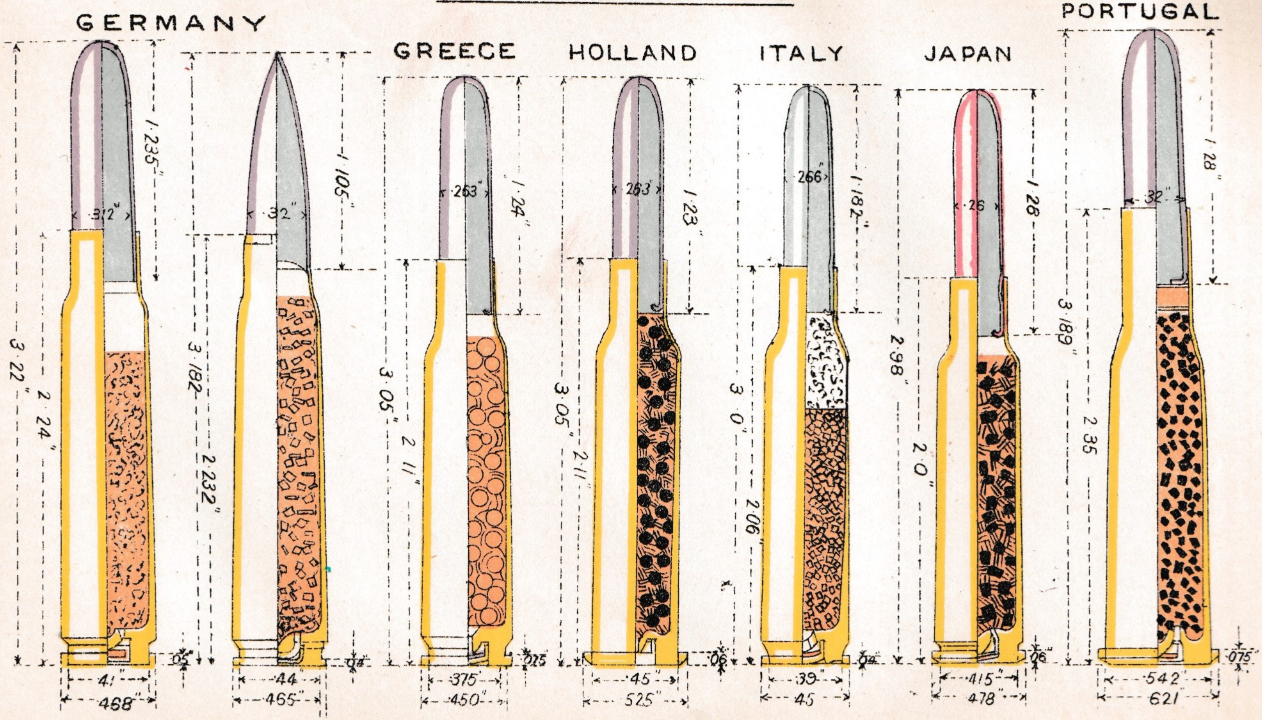

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Plate LIX

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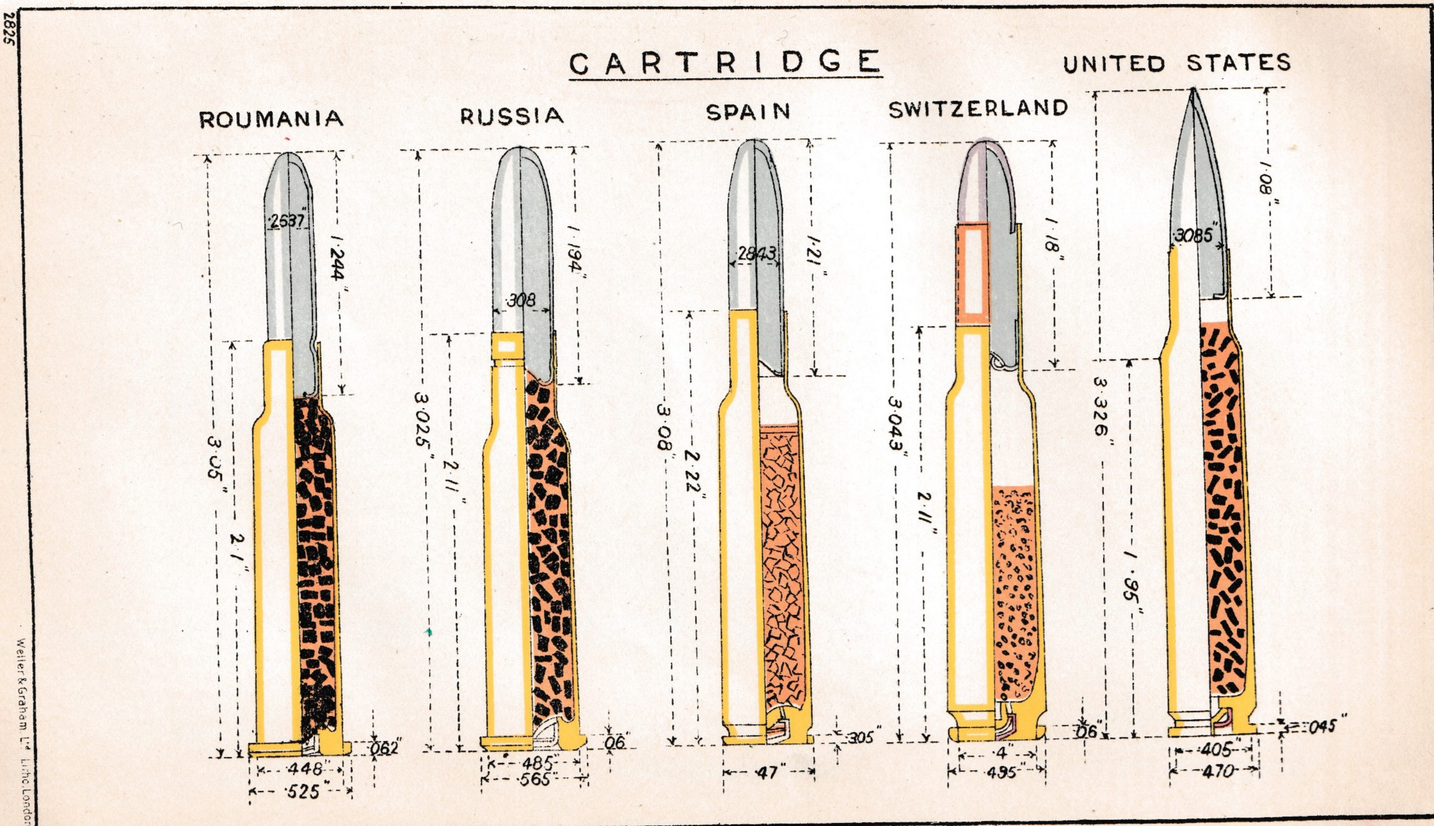

Plate LX

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2825.

CHARGERS.

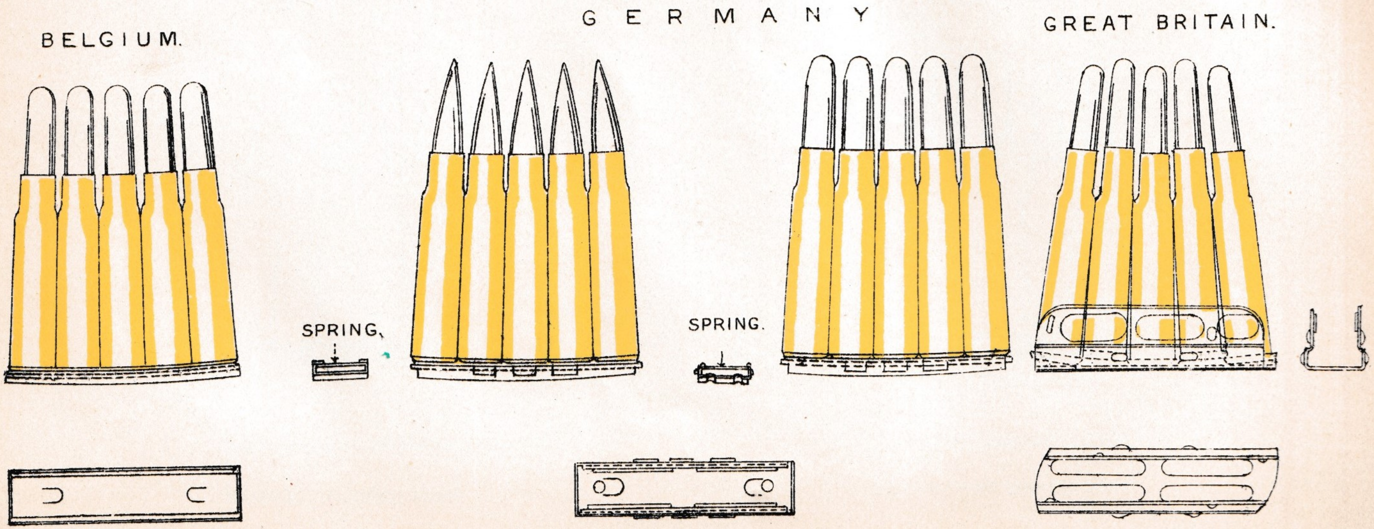

Plate LXI

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CHARGERS.

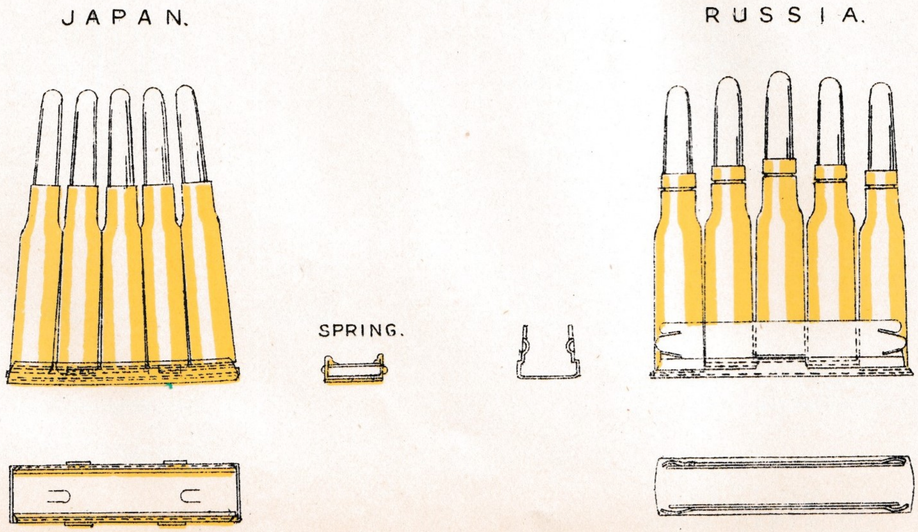

Plate LXII

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CHARGERS.

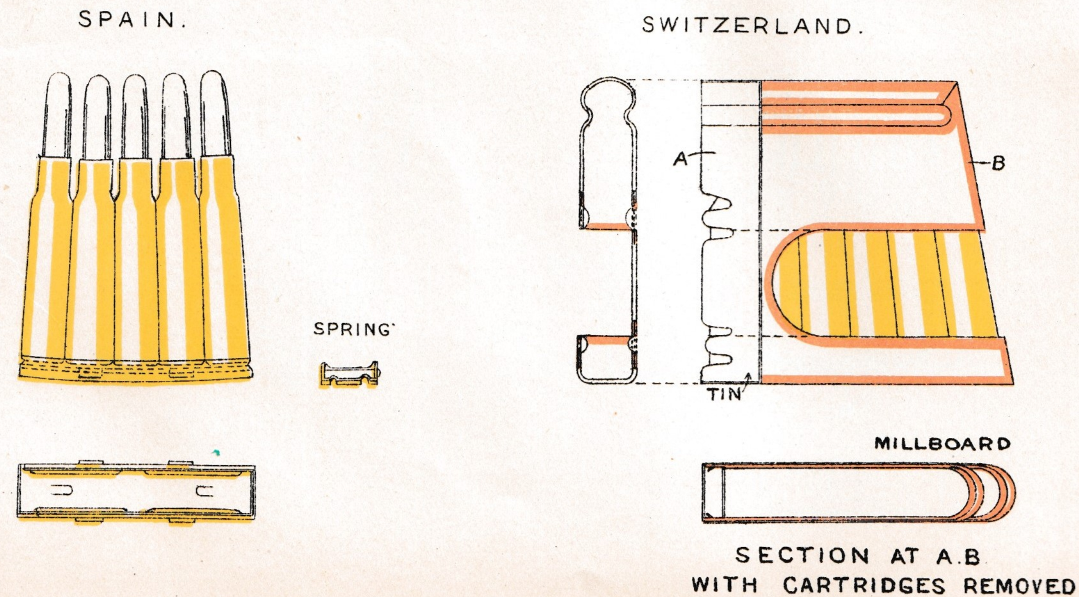

Plate LXIII

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CLIPS.

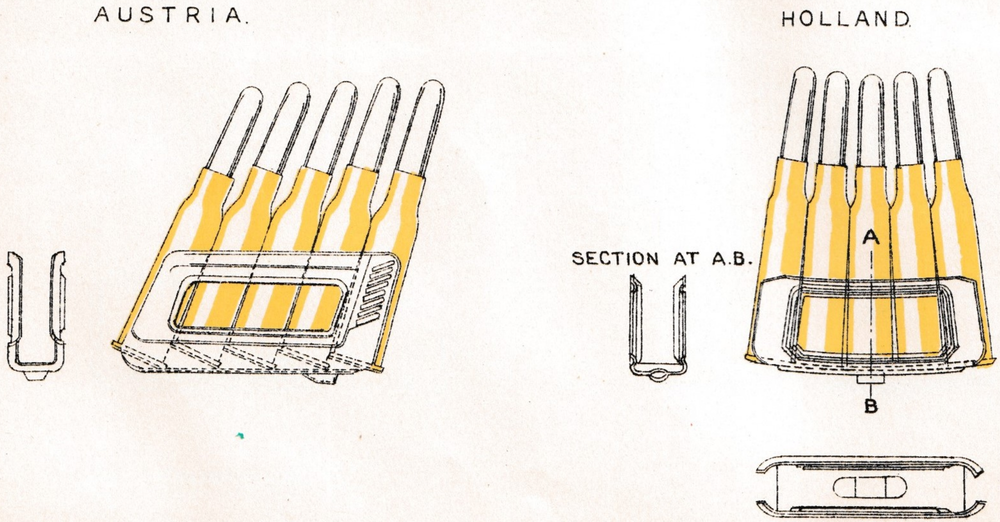

Plate LXIV.

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CLIPS.

ITALY. ROUMANIA.

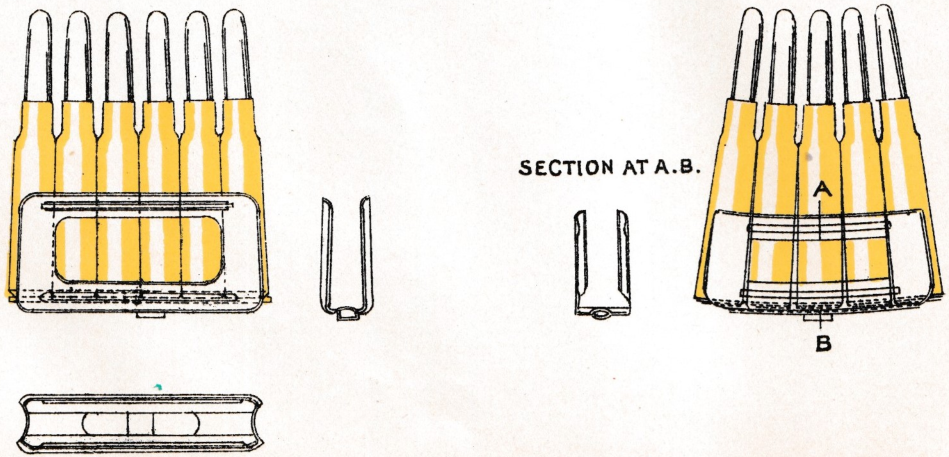

Plate LXV.

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PART II.

The Ballistics of Small Arms.

CHAPTER I.

Definitions and Units.

Ballistics is the science which investigates the motion of projectiles. It may, for our purposes, be conveniently divided into—

(*a.*) *Interior Ballistics*, which deals with the motion of the bullet while in the bore of the rifle.

(*b.*) *Exterior Ballistics*, which deals with the motion of the bullet after it has left the muzzle of the rifle.

The *axis of the rifle* is the straight line passing down the centre line of the bore.

The *calibre* is the diameter of the bore in inches measured across the lands.

The *line of sight* is the straight line passing through the sights of the rifle and the point aimed at.

The *angle of sight* is the angle which the line of sight makes with the horizontal plane (S, fig. 1).

When the line of sight slopes downwards, as in fig. 1, A, the angle of sight is usually called the *angle of depression.*

The *line of departure* is the direction in which the shot is moving on leaving the rifle; or in other words, a tangent to the trajectory at the muzzle.

The *angle of departure* is the angle which the line of departure makes with a horizontal plane (D, fig. 1).

The *trajectory* is the curve described by the C.G. (centre of gravity) of the bullet in flight (*i.e.*, the curved line GT in fig. 1, A, B).

Range is the distance GT from the muzzle of the rifle G to the intersection T of the trajectory with the line of sight.

The *plane of sight and departure* is the vertical plane passing through the lines of sight and departure respectively.

Drift is the deflection of the projectile from the vertical plane of departure, due to the rotation imparted by the rifling of the rifle. It is sometimes termed Deviation.

The *quadrant angle* is the angle (Q, fig. 4) which the axis of the rifle, when laid, makes with the horizontal plane.

It is termed quadrant *elevation* or *depression* (Q.E. or Q.D.), according as the rifle is laid above or below the horizontal

plane; the term *depressed fire* means that a rifle is fired at a quadrant angle of depression (Q.D.).

The *angle of tangent elevation* (T.E.) is the angle between the axis of the rifle and the line of sight (T, fig. 1).

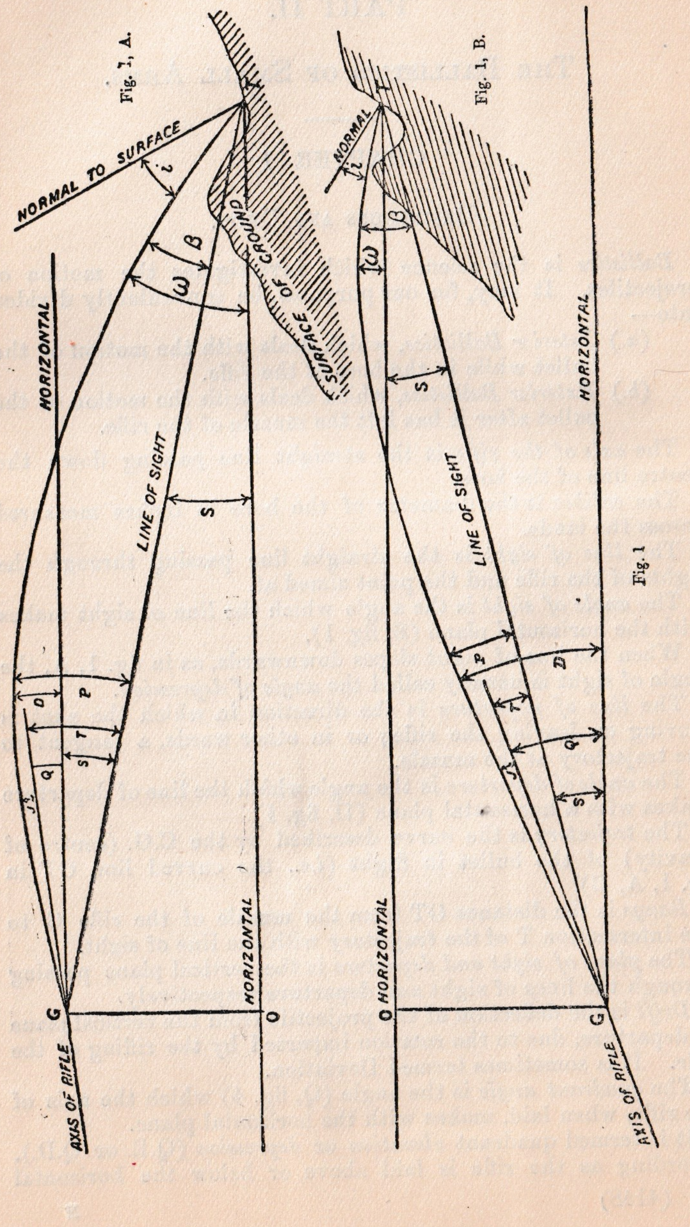


Fig. 1

The angle (S) made by the line of sight with the horizon must be added or subtracted to obtain the *quadrant angle* of elevation or depression from the *tangent angle*; subtracted in fig. 1, A, added in fig. 1, B.

The *angle of projection* is the angle between the line of departure and the line of sight (P, fig. 1).

Jump is the angle between the line of departure and the axis of the rifle before firing (J, fig. 1). If the angle of departure is greater than the quadrant angle, the jump is said to be positive, if less negative.

The *angle of descent* is the angle which a tangent to the trajectory at the point of impact makes with the line of sight (β, fig. 1).

The *angle of arrival* is the angle which a tangent to the trajectory makes with the horizontal plane (ω, fig. 1).

The *angle of incidence* is the angle which a tangent to the trajectory at the point of impact makes with the normal to the surface struck (i, fig. 1).

In the "Appendix to Training Manuals," and in "Musketry Regulations," we have also the following definitions:—

The *first catch* is that point where the bullet has descended sufficiently to strike the head of a man whether mounted or standing, kneeling, lying, etc.

The *first graze* is the point where the bullet, if not interfered with, will first strike the ground.

The *dangerous space* for any particular range, is the distance between the first catch and the first graze.

Physical Definitions.

The *velocity* of a body is its rate of change of position.

The velocity of a body is measured, if constant, by the number of units of length (feet) described in the unit of time (the second).

Thus, if s feet is described in t seconds, the velocity, v, is given by—

$$v = \frac{s}{t} \text{ feet per second (f.s.)}$$

If the velocity is variable then $\frac{s}{t}$ is the average velocity in f.s. with which s feet is described in t seconds, and the actual velocity at any point is the average velocity over a very small distance enclosing the point.

Acceleration is the rate of change of velocity.

It is measured, if constant, by the growth of velocity (in f.s.) per second (abbreviated to f.s.^{2}).

Thus if the velocity grows at a constant rate from V to v in t seconds the acceleration a is given by—

$$a = (v - \text{V})t,$$
$$v = \text{V} + at.$$

If the velocity is decreasing instead of increasing we may consider the acceleration as negative, and it is then frequently referred to as a retardation.

As a familiar example of a constant acceleration we may take the acceleration of gravity. Denoting this by g (= 32 approx.) the velocity of a body falling freely will be accelerated g f.s. per second, whereas if projected vertically upwards, the velocity will be retarded g f.s. per second.

Muzzle velocity is the velocity of a projectile on leaving the muzzle.

Remaining velocity is the velocity at any point of the trajectory.

Striking velocity is the velocity at the point of impact.

Force is that which produces, tends to produce, or prevents motion in a body.

The unit of force employed in ballistics is the attraction of the earth on one pound or one ton.

Strictly speaking, it is the tension of a thread or rope, supporting one pound or one ton, thus allowing for a slight discount in the attraction of the earth due to its rotation. This unit of force is a statical or gravitational unit, and it changes slightly, but quite inappreciably for our purposes, for different places on the earth's surface.

Stress is the action of balancing forces; it is estimated in units of force per unit area, generally in pounds or tons per square inch, abbreviated in writing to lb./in.^{2} or tons/in.^{2}

Pressure is a stress tending to prevent the approach of two bodies together.

Tension is a stress tending to prevent the separation of two bodies.

Total thrust or pull P is the product of the stress p and the area A in square inches over which it acts, or

$$P = pA, \qquad p = P/A.$$

Strain is the deformation produced by stress.

Compression is the strain produced in a body by pressure.

Extension is the strain produced in a body by tension.

The *limit of elasticity* of a substance is the least stress producing permanent strain.

The *tenacity* of a substance is the breaking tension.

Elasticity and tenacity are expressed in tons on the square inch in practical work.

Units.

The British units employed in ballistics are unfortunately very numerous; care is therefore necessary to avoid confusion and consequent mistakes in calculations.

Length—

Yards for ranges and in Table M.

Feet for heights of trajectories, and also for distances in Table K.

Inches for calibres of rifles.

Weight—

Tons and cwt. for the weights of ordnance.

Lbs. and ozs. for the weights of rifles, and projectiles and charges of ordnance.

Grains (gr.) for the weights of bullets and charges of small arms.

7000 grs. = 1 lb. avoirdupois.

Angles are measured in degrees and minutes, the circumference of a circle being divided into 360° (degrees), and each degree into 60′ (minutes).

In the *Metric system*, which is largely employed in the United Kingdom, and universally on the Continent, ranges and heights are given in metres (m.), and velocities in metres per second (m.s.).

1 metre = 1·09 in yds. = 3·28 ft. (approx.)

Calibres are in millimetres (m.m.), sometimes in centimetres (c.m.) for larger guns.

1 millimetre = 0·1 centimetre = 0·001 metre = 0·0394 in., or 1 in. = 25·4 m.m.

Weights are in kilogrammes (kg.); or for small weights, such as rifle bullets and charges grammes (gm.) are employed.

1 gm. = 0·001 kg. = 15·4 gr. or 1 kg. = 2·2 lb. nearly.

A more extended series of equivalents will be found in Table F.

"This part of the Treatise is written solely with the view "of imparting instruction in the methods of ballistic calculation "in as simple a form as possible. The values of the ballistic "coefficients and coefficients of reduction given herein must be "regarded as merely illustrative, as the discussion of the "variations to which these coefficients are subject has, for the "sake of clearness, been curtailed." Page 193.

CHAPTER II.

Interior Ballistics.

Interior Ballistics was defined in Chapter I. as dealing with the motion of the bullet while in the bore of the rifle. It investigates the circumstances of the motion, and the relations between the pressure, volume, and temperature of the gases evolved by the explosion of the charge, also the work done by the expansion of these gases, until the bullet leaves the bore with a certain velocity, termed the muzzle velocity, and enters the domain of Exterior Ballistics. The gases of the charge actually continue to exert an influence on the velocity of the bullet after it has left the muzzle, the influence lasting until the pressure of the gases has fallen to atmospheric pressure.

It is first necessary to define and explain some of the terms which will be frequently met with.

Force and the unit of force have already been defined in Chapter I.

If a force of P lbs., acting on a weight of W lbs., produce an acceleration a f.s.^{2}, we have by Newton's 2nd Law of Motion

$$\frac{a}{g} = \frac{\mathrm{P}}{\mathrm{W}} \dots\dots\dots\dots\dots\dots \quad (1).$$

Now suppose a force of P lbs. to act on a weight of W lbs. through s feet and for t secs., and to generate a velocity v f.s. from rest.

Then from (1) and the fundamental equations of motion with constant acceleration

$$\tfrac{1}{2}v^2 = as = \frac{\mathrm{P}gs}{\mathrm{W}},$$

$$v = at = \frac{\mathrm{P}gt}{\mathrm{W}}.$$

Whence

$$\mathrm{P}s = \tfrac{1}{2}\frac{\mathrm{W}v^2}{g} \dots\dots\dots\dots\dots \quad (2).$$

$$\mathrm{P}t = \frac{\mathrm{W}v}{g} \dots\dots\dots\dots\dots\dots \quad (3).$$

The product Ps of a force P lbs., acting through s feet in its own direction, is called the *Work* done by the force in ft. lbs.; and from (2) $\tfrac{1}{2}\frac{\mathrm{W}v^2}{g}$ is also in ft. lbs., and is called the *kinetic energy* of a body weight W, moving with a velocity v f.s.

The product Pt of a force of P lbs. acting for t secs. is called its *impulse*, and is in second-pounds. Again, from (3) $\frac{\mathrm{W}v}{g}$

is also in second-pounds, and is termed the *momentum* of W lb , moving with velocity v f.s.

Work done by a uniform force can be represented graphically by a rectangular area in which the height is proportional to the force P, and the base to the distance s through which the force acts.

Thus, if AD is proportional to P, and AB to s (fig. 2), the area DB will represent graphically the work done.

Suppose at some point C on AB (fig. 3) the pressure suddenly alters; if at C we erect a perpendicular and mark off on it CF, proportional to the new pressure, and complete the rectangle FB, the work will be represented by the sum of the two areas DC and FB.

Fig. 2.

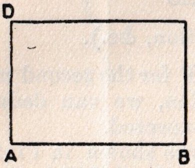


Fig. 3.

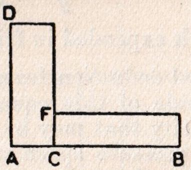
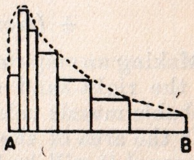


Fig. 4.



If the pressure changes more than once we must take a greater number of rectangles (fig. 4), and the sum of the areas then represents graphically the work done by a pressure P which has suddenly changed in magnitude several times in acting on the body, over the distance AB.

Now, suppose the pressure to change in magnitude, but to do so gradually as shown by the dotted line in fig. 4, in this case the number of rectangles becomes indefinitely increased, and the work done is represented by the area enclosed by the curved line (the locus of the corners of an indefinite number of rectangles).

When the charge of cordite is ignited in the rifle by means of the cap, gas is evolved and exerts an increasing pressure in the interior of the chamber and base of the bullet. This increasing pressure soon becomes sufficiently great to force the bullet into the grooves of the rifling and start it on its travel up the barrel. The pressure when the bullet starts to move is about 0·5 to 1 ton/in^2. As the bullet travels, the pressure increases very rapidly until when the greater part of the propellant is burnt a point of maximum pressure is reached. This will occur when the bullet has travelled a few inches.

The pressure then gradually falls to a certain muzzle pressure when the bullet leaves the bore, and there is then a further fall of the pressure of the gases from muzzle to atmospheric pressure.

If we plot the travel of the bullet as abscissæ and the corresponding pressures as ordinates, as can be done from the results of experiments, we obtain what is known as a *pressure space curve*.

Plate I shows a more or less diagrammatic curve of this nature for the ·303 rifle, the travel being in inches and the pressure in ton/in^2.

The area A, B, C, D can then be measured with a planimeter, or estimated by some such method as Simpson's rule.

This will represent the work done by the gases of the propellant in in.-tons per in.^{2} of cross section of the bullet while it travels from A to D.

This work is principally expended in expelling the bullet (weight w lb. say) with a muzzle velocity of say V f.s., but a part is used up in friction, rotation of the bullet, and conduction of heat to the barrel.

If F be the total work in ft.-tons, we will have

$$F = \tfrac{1}{2} w \frac{V^2}{g} \times \frac{1}{2240}$$

$$+ \text{ (work expended in friction, \&c.).}$$

Making an empirical deduction from F for the second member of the right-hand side of this equation, we can deduce the probable muzzle velocity that may be expected.

If the area of the pressure space curve shown in Plate I, be measured it will be found to represent about 156 in.-tons per sq. in. work done.

Taking the effective area of the bore as $\frac{\pi}{4}(0 \cdot 31)^2 = 0 \cdot 0755$ in.^{2}, we have for the total work up the bore in ft.-tons

$$\frac{156}{12} \times 0 \cdot 0755$$

$$= 0 \cdot 982 \text{ ft.-tons,}$$

making a deduction of say 10 per cent. for friction, we have equating the work to the muzzle energy,

$$0 \cdot 884 \times 2240 = \tfrac{1}{2} w \frac{V^2}{g}$$

where w = weight of bullet = $\frac{215}{7000}$ lb., and V = muzzle velocity in f.s., whence V = 2040 f.s. nearly, which is about the muzzle velocity attached with this rifle.

We will now consider some of the factors which influence the maximum pressure reached, and the travel of the bullet at which this is attained.

Cordite and indeed, practically all modern smokeless powders for military purposes are, to all intents and purposes "Colloids," that is to say, they are solid bodies impervious to the gases produced on explosion, as opposed to porous bodies, and consequently only burn on the surface. For instance, a stick of cordite if lit all over, as is the case in a rifle chamber, will burn only on the surface, and as burning proceeds the diameter of the stick gets smaller and smaller till it is finally all converted into gas. If cordite, in the solid cylinder form, is blown out, partly unconsumed, from a gun or rifle it is found to be very

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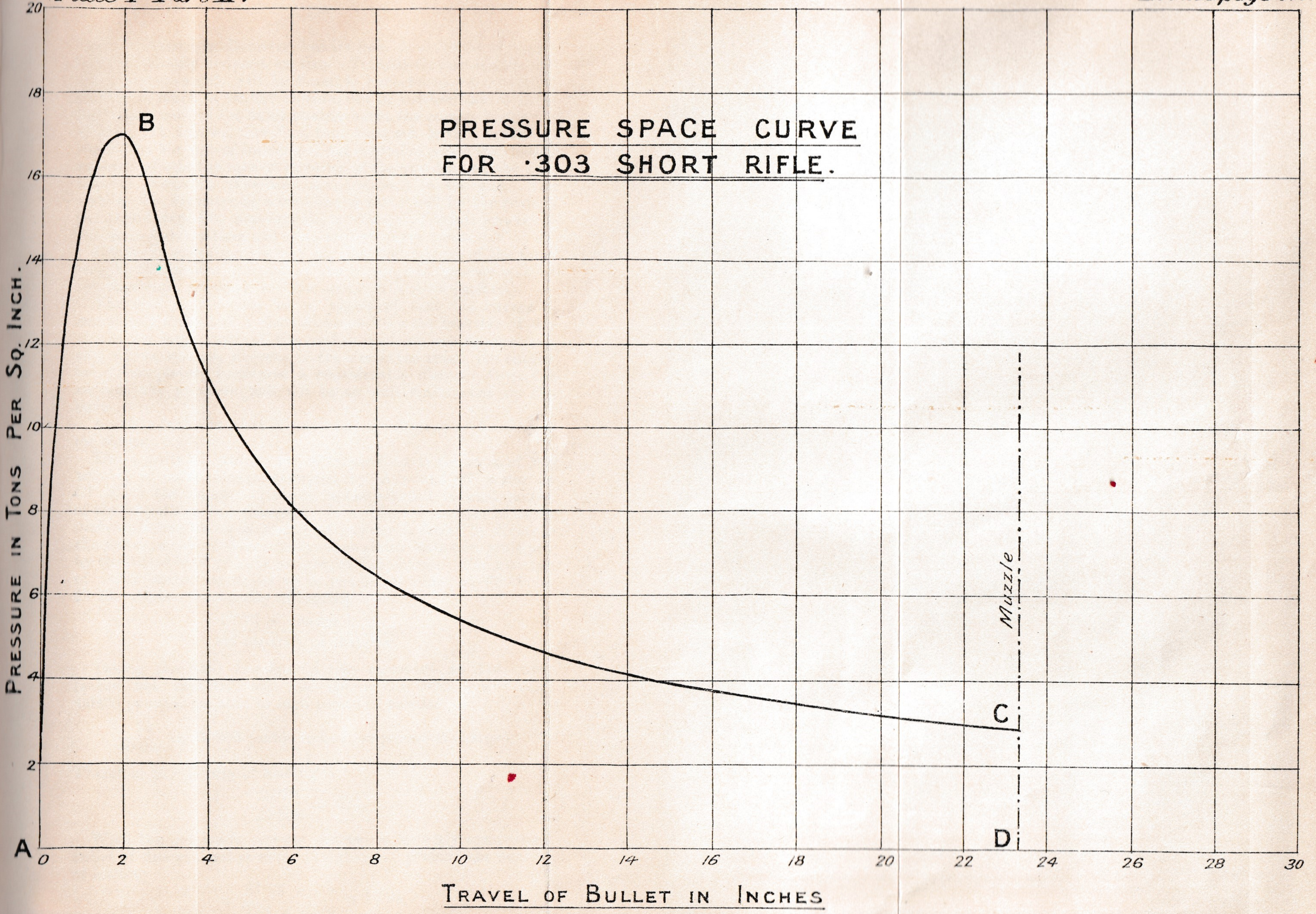

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Weller & Graham, Ld. Litho. London.

much decreased in diameter, but its form is still that of a solid cylinder merely reduced in size. Tubular cordite blown out, partly unconsumed, will be found to have burnt on the inside surface as much as on the outside, but in neither case is there any appearance of the flame having burnt the cordite below the surface. It follows, therefore, that here we have a means of regulating the rate of burning of our explosive, since the surface exposed affects the rate of burning of the powder and the consequent pressures, velocities, &c., obtained in the gun. The smaller the diameter of a cord the greater will be the surface per pound exposed, consequently a charge of small size cords will burn quicker than one composed of larger cords.

Generally speaking, we may say that for charges of the same weight, the smaller the size of the cordite the greater will be the maximum pressure, and the sooner will it be reached.

The size should also be so regulated that the charge is completely consumed a short distance from the muzzle; if the size is too large some of the cordite is blown out unconsumed and will be wasted, whereas, if the size is too small, the charge being completely consumed a considerable distance from the muzzle, the pressure will not be so well maintained up the bore.

Another factor is what is known as the *Density of Loading of the charge.*

The density of loading above referred to, is the ratio of the number of cubic inches occupied by a pound of water at 62° F. to the number of cubic inches allotted to each pound of the propellant, in a chamber. In a rifle, the number of cubic inches allotted to each pound of powder is found by dividing the net capacity of the cartridge case (with bullet in position) by the number of pounds weight of the charge. The number of cubic inches occupied by a pound of water at 62° F. is 27·73. Hence the density of loading is—

$$\frac{27{\cdot}73 \times \text{charge in lbs.}}{\text{net capacity of chamber.}}$$

Taking the ·303 Lee-Enfield rifle cartridge as ·174 cubic inches net capacity, and the charge as 30·5 grains (*i.e.*, ·00436 pounds) we allot to each pound of powder :—

$$\frac{\cdot 74}{\cdot 00436} = 39{\cdot}908 \text{ (cubic inches per pound of charge).}$$

Therefore our density of loading is

$$\frac{27{\cdot}73}{39{\cdot}908} = \cdot 695.$$

With the old black powder charge—a strongly compressed pellet of fine grained powder—weighing 70 grains; the density of loading

$$= \frac{27{\cdot}73 \times 70}{\cdot 174 \times 7000} = 1{\cdot}594.$$

The effect of a high density of loading or tight packing of the charge is to reduce the space into which the gases, evolved by the commencement of the burning of the propellant, can expand, and consequently a more rapid rise of pressure occurs than with the same powder loaded at a lower density of loading.

In order to show the effects of combinations of size, density of loading and nature of explosive, the following results obtained in the ·303-inch are given:—

Nature.	Charge.	Velocity mean.	Pressure. Maximum mean allowed.
(1) Mark I black powder cartridge.	70 grains special fine-grained powder, compressed into a pellet.	1830 f.s.	19 tons.
(2) Mark II cordite service cartridge.	31 grains size, $3\frac{3}{4}$.	2000 f.s.	16·5 „
(3) Mark II second proof cartridge.	32 grains size, 3.	Not considered	20 „
(4) Mark II cordite service cartridge, exptl. load.	33 grains size, $3\frac{3}{4}$.	Not considered	19·3 „

Comparing (1) and (2) the effect of the slow burning cordite in giving a moderate maximum pressure and maintaining the pressure well along the bore is clearly shown, since it gives 9 per cent. more velocity for 13 per cent. less maximum pressure. The impossibility of bringing down the rate of ignition and burning of, and the consequent pressure given by, the black powder, even by very heavy compression into the pellet form, with a very great increase of density and hardness, is also clearly shown.

Comparing (2), (3) and (4), it will be noted how great an effect a slight reduction in the diameter of the cordite has on the resulting pressure arising from more rapid ignition and burning. The second proof cartridge gives at least $3\frac{1}{2}$ tons more pressure than the service cartridge with an increase of charge of only 1 grain; whereas *double* this increase of charge (viz., 2 grains, as at (4)), the diameter of the cordite remaining the *same*, gives an increase of 2·8 tons only.

It should be specially noted that examples (3) and (4) are cited as instancing rise of *pressure only*.

Size 3 is too small a size for use in the ·303-inch if high velocities are wanted.

The actual temperature of the charge when fired has an important effect on the ballistics. The higher the temperature the greater will be the maximum pressure and the higher the muzzle velocity.

Thus with the ·303 rifle and the service cartridge at a temperature of 60° F., the maximum pressure will be about 16 ton/in.^{2} and muzzle velocity 2,060 f.s., while if the charge be warmed to 120° F. the figures will approximate to 18 ton/in.^{2} and 2,150 f.s.

Over a range of about 20° F. the muzzle velocity may be taken to alter at the rate of 2 f.s. for every degree.

In the space available for this part of the subject in a Text Book of this nature, it has not been possible to give more than an outline of some of the principles. For a more extended treatment a consideration of the experiments and investigations of Sir Andrew Noble, Sir Frederick Abel, and Major Mansell is necessary, while the methods and formulæ of Sarrau, Charbonnier, and Ingalls demand examination and attention.

The systematic treatment of interior ballistics however, from a variety of causes, presents such difficulties that up to the present we are frequently driven back to purely empirical methods for practical use, and of necessity for a first approximation.

By plotting the results of a number of experiments on logarithmic paper empirical formulæ of the monomial type can be obtained, and such are very largely employed.

Thus it is found for Mark I cordite that for a given size of cordite

$$P \propto \varpi^{1 \cdot 2} \text{ nearly} \quad . \quad . \quad . \quad . \quad (1)$$

where P is the maximum pressure, and ϖ is the weight of the charge; while

$$V \propto \varpi^{0 \cdot 6} \text{ nearly} \quad . \quad . \quad . \quad . \quad (2)$$

where V is the muzzle velocity. Again for a charge of given weight

$$P \propto \left(\frac{1}{D}\right)^{1 \cdot 2} \text{ nearly} \quad . \quad . \quad . \quad . \quad (3)$$

where D is the diameter of the cords used in making up the charge.

As an example of the use of these formulæ we may take the following problem:—

31 gr. of cordite, size $3\frac{3}{4}$, are found to give a maximum pressure of 16 tons/in.^{2} What maximum pressure may be expected with 33·5 gr. of size 3?

From (1) 33·5 gr., size $3\frac{3}{4}$, would give a pressure of

$$16 \times \left(\frac{33 \cdot 5}{31}\right)^{1 \cdot 2} = 17 \cdot 55 \text{ ton/in.}^2$$

And from (3) 33·5 gr., size 3, would give a pressure of

$$17 \cdot 55 \times \left(\frac{3 \cdot 75}{3}\right)^{1 \cdot 2} = 23 \text{ tons/in.}^2 \text{ nearly.}$$

The realized pressure is stated to be 24 ton/in.^{2}

Another useful empirical formula is that given by Captain Hardcastle as holding good for the 0·303 rifle with a maximum chamber pressure of 20 ton/in.^{2} and cordite Mark I.

$$V = 5050 - 180 \sqrt{w},$$

where V is the muzzle velocity in f.s., and w the weight of the bullet in grains.

Thus 3,000 f.s. might be expected with a 130 gr. bullet, and 2,500 f.s. with a 200 gr. bullet.

The Measurement of Maximum Pressure and Muzzle Velocity.

To measure the maximum pressure attained on firing a rifle, a crusher gauge is used; this consists of a copper cylinder with a central longitudinal hole in it for the striker to pass through. This "copper" is compressed by the action of the powder gas so that it becomes shortened, the difference between the length measured before, and after firing, is called its compression, and the amount of compression is a direct measure of the actual maximum pressure to which it has been subjected.

The measurements of the coppers before compression are as follows:—

Length.
External diameter.
Diameter of longitudinal hole.
Area of annulus.

It is first necessary to "calibrate" the coppers, *i.e.*, to determine what each compression represents in tons/inch^2.

To do this a large number of coppers are compressed in a press with suitable dead weights and the compression for each dead weight noted, and from the mean results we can draw up a table giving corresponding compressions and pressures.

It is found in practice that it is impossible to ensure that all copper as supplied by the trade is of constant homogeneity, and it is therefore necessary to first determine, by pressing in a statical press, whether a copper is "hard," or "soft," and having found its degree of hardness or softness, an allowance is made for this in the tables.

Thus, if a hard copper is used for taking a pressure in a gun, the true pressure will not be recorded, in fact it will be greater than that recorded, owing to the hard copper resisting compression more than a normal copper, therefore a certain amount has to be added to the pressure as given by the tables, and *vice versâ* for the soft coppers. (As a general rule for small-arm copper work, all this information is given on the tables for each set of coppers used.) Even if we could always ensure having coppers of exactly the same homogeneity, it would still be necessary to have them pressed, before firing, to slightly less than the compression, which will be caused by the powder gas. The reason for this is that the piston of the

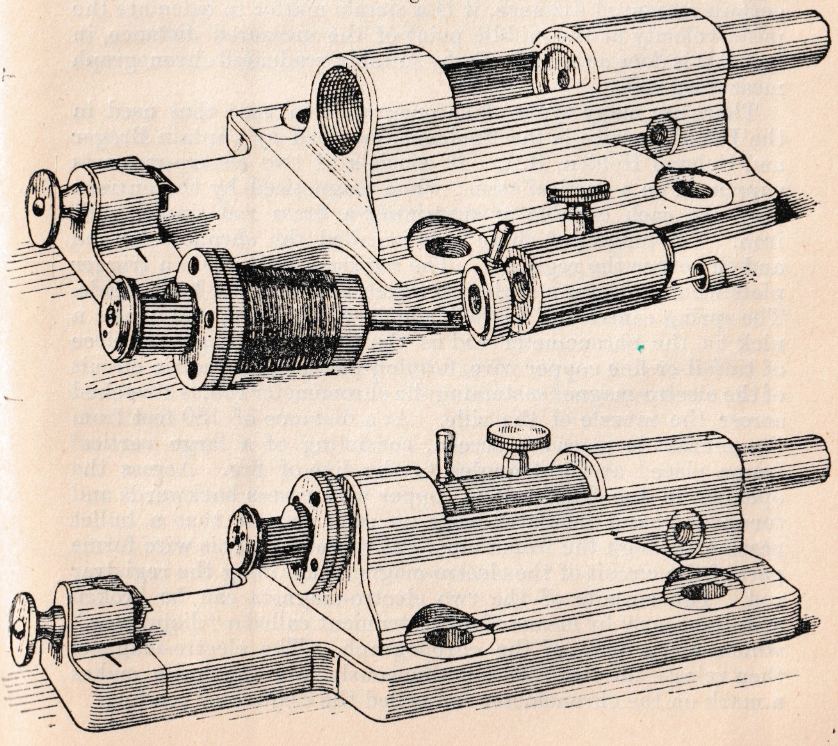
crusher gauge (or cartridge case in small-arm pressure work) should have as little movement as possible so as to obviate any possibility of dynamical action affecting the results obtained, and also to ensure better sealing of the cartridge case.

The arrangements for taking pressures with small-arm ammunition are generally as follows:—

A very strong barrel, called a pressure barrel (see illustration), is provided with a breech arrangement on the wedge principle; the cartridge, having previously been dipped from the base up to the neck in Rangoon oil, is placed in the chamber, its base resting against a hollow piston containing the copper, and the whole kept in position by circular wedges, screwed up from the rear by means of a screwed plug containing the firing arrangements. The striker passes through the screwed plug, wedges, piston and copper, and so is free to move forward on to the cap; on firing, the oiled case is forced back on to the piston, thus compressing the copper which is then taken out and measured. The pressure in tons/inch^2 is then read off the table, by referring to the particular column to which the copper used belongs, as regards hardness or softness.

Fig. 5 shows a pressure barrel assembled and dismantled.

Fig. 5.



The actual area on which the gas acts has been founded on a large number of experiments with cases provided with "Morse" bases which were movable and had a definite area, but this system would not allow of ordinary service ammunition being used for proof and pressure work, and it was therefore superseded by the "oiled" case system, and the tables were drawn up for the latter to be in accord with the former.

Most Continental nations use radial pressure gauges screwed into the barrel just in front of the base of the cartridge, but the results obtained are not very reliable owing to very small coppers having to be used and also because local high pressure and dynamical action are more likely to be registered. As a general rule, this system gives considerably lower pressures than are obtained by the "oiled" case system, and, further, it is necessary to have a small hole in the side of the case which is not always easy to place in exact coincidence with the screwed hole in the gun into which the gauge is screwed; it also necessitates special cases, thus precluding the possibility of using ordinary service ammunition, which is a distinct advantage of the "oiled" case system.

To take velocities of projectiles, the apparatus used is called a chronograph, which is an instrument for measuring time.

Knowing the time taken by the bullet to pass over a certain measured distance, it is a simple matter to calculate the mean velocity at the middle point of the measured distance, in fact this is done automatically by suitably graduated chronograph measuring rods.

There are many types of chronographs in use; that used in the British service is the Boulengé, modified by Captain Bréger and Colonel Holden, R.A. It consists of two electro-magnets supported on a vertical stem; when magnetised by the current they are each capable of sustaining a brass rod tipped with iron. The longest of these rods is called the chronometer rod and the other the registrar. The registrar falls upon a trigger plate which releases a spring to which is attached a knife blade. The spring causes the knife blade to fly forward and make a nick in the chronometer rod as the latter is falling. A piece of tinfoil or fine copper wire, forming part of the electric circuit of the electro-magnet sustaining the chronometer rod, is stretched across the muzzle of the rifle. At a distance of 180 feet from the muzzle is placed a screen, consisting of a large vertical frame placed at right angles to the line of fire. Across the opening in the frame a fine copper wire passes backwards and forwards round insulated pegs on each side, so that a bullet passing through the frame must cut the wire. This wire forms part of the circuit of the electro-magnet sustaining the registrar rod. The circuits of the two electro-magnets can be broken simultaneously by means of an instrument called a "disjunctor," which forms part of the chronograph. The electro-magnets then release the two rods simultaneously, and the knife makes a mark on the chronometer rod called the disjunctor reading.

When the velocity of a bullet is being taken, the bullet on issuing from the muzzle severs the wire stretched across it, and the chronometer rods begin to fall, and when the bullet passes through the screen it cuts the wire stretched across it, and the registrar rod then begins to fall. The nick made by the knife blade will be some distance from the nick made when the two rods were released simultaneously. By measuring this distance with a suitably graduated vernier scale, the average velocity with which the bullet traversed the 180 feet between the muzzle and the screen can be read off. This average velocity is approximately the actual velocity at half the distance, viz., at 90 feet. The method of working out the muzzle velocity is explained in Chapter V. For a full description of the instrument and for the method of using and adjusting it, see the "Text Book of Gunnery."

CHAPTER III.

MOVEMENTS OF THE RIFLE ON FIRING.

The movements of the rifle on firing may be considered under four headings :—

1. The recoil or backward motion of the rifle.
2. The upward movement of the muzzle, or rotation of the rifle about its centre of gravity.
3. The vibrations of the rifle.
4. The twisting movement of the rifle about its axis.

(1) Recoil. The recoil is produced by the explosion of the gas generated by the explosion of the charge, forcing the bullet in one direction and the rifle in the other. The time during which the recoil is attaining its maximum velocity may be divided into two periods :—

1. From the first movement of the bullet until its exit from the muzzle.
2. From the exit of the bullet from the muzzle until the pressure of the gas in the bore has fallen to atmospheric pressure.

In the Text Book of Gunnery, Part I, 1907, page 140 *et seqq.*, it is shown, from a consideration of the equations of motion, that the recoil velocity u is connected with the velocity v of the bullet at any time while the bullet is in the bore of the rifle by the equation

$$(W + \tfrac{1}{2}\varpi)\, u = (w + \tfrac{1}{2}\varpi)\, v \quad \ldots\ldots\ldots \quad (1).$$

Where W = weight of recoiling parts,
w = weight of bullet,
ϖ = weight of charge,

all in pounds.

And this equation will give us the recoil velocity at the muzzle when the velocity of the bullet is V f.s., the muzzle velocity.

But after the bullet has left the muzzle the gases escape with some unknown high velocity and mingle with the surrounding air, imparting to it a considerable momentum (this is frequently referred to as the "blast" of the powder gases). Meanwhile the pressure on the base of the bore must last an appreciable time longer, so that the rifle receives an additional recoil after the bullet has left the muzzle, and this recoil is greater as the weight of the charge and the powder pressure up to the muzzle is greater.

To allow for this in practice in determining the maximum velocity of recoil, V, the following empirical formula is employed

$$WU = (w + C\varpi)V \quad \ldots\ldots\ldots\ldots \quad (2),$$

where C is a constant depending on the nature of the pro-

pellant, and is determined by experiment. For cordite $C = 2$ approximately.

Thus with the short Lee-Enfield rifle we have

$W = 8{\cdot}15$ lb. (without bayonet), $W = \frac{215}{7000}$ lb., $\varpi = \frac{31}{7000}$ lb.,

$V = 2060$ f.s., whence, from (2),

$$8{\cdot}15 \times V = (215 + 2 \times 31) \times 2060$$
$$U = 10 \text{ f.s.,}$$

nearly, the maximum recoil velocity.

The corresponding energy of recoil E, will be given in ft.-lbs. by

$$E = \tfrac{1}{2} W \frac{U^2}{g} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$
$$= \tfrac{1}{2} \times \frac{8{\cdot}15 \times (10)^2}{32}$$
$$= 12{\cdot}75 \text{ ft.-lbs.}$$

The physiological sensation produced by the recoil is generally termed the "kick." It is probable that the kick is intensified by the rapidity of the first rise in the velocity, which with the Lee-Metford rifle is attained in about ·0006 seconds. The shorter the time in which this first maximum is reached, and the greater the velocity, the more violent the kick; from this it follows that the kick, though, no doubt, depending chiefly on the energy of recoil, cannot be said to be strictly proportional to the latter alone in various arms and with different powders.

The kick of a rifle is an important point to consider, for if it is severe it causes a great waste of time and ammunition in training the soldier to become accustomed to it, and to fire the rifle without any involuntary movement of the body. Even experienced shots, after their shoulders have been bruised by firing a number of rounds from a rifle that kicks severely, are liable to fire unsteadily. The improvement in musketry since the introduction of the magazine rifle is partly due to the great diminution in the kick, for the kick of the Martini-Henry rifle was more severe than that of any of the military rifles of its day.

The kick is reduced by pressing the rifle firmly against the shoulder, and by letting the latter come back freely when the rifle recoils, for then part of the weight of the firer's body is added to the rifle; therefore, the velocity of recoil of the latter is reduced, and the kick partakes more of the nature of a push. If the rifle is held very loosely, or is fired when snap shooting, before it touches the shoulder the kick becomes a blow, which is more damaging to the firer's shoulder than the kick from the rifle when it is properly held.

A sportsman feels the kick of his weapon much more when firing at the target than when firing at game, for in the latter case, his attention is fixed on his quarry, and he performs the

required movements automatically without bracing his body to resist the recoil.

The energy of recoil given above for the Lee-Enfield rifle (12·75 foot lbs.) is well below the maximum energy of recoil advisable for a military rifle which should not exceed 15 foot lbs.

The recoil of a 12 bore shot gun is double this amount, and although not excessive in the field, is very apparent when firing at a target. The following table, giving the particulars of the recoil of a 12 bore gun, are taken from an article by Captain Journée in the "Mémorial des poudres et salpêtres," Volume III. The gun was suspended by long strings, and the velocity of recoil was ascertained by attaching to the gun a tuning fork, the vibrations of whose arm traced a wavy line (similar to those in Figs. 1 to 7, Plate IV) on a plate placed parallel to the direction in which the weapon recoiled. As the time occupied by each vibration of the tuning fork is constant, and is known beforehand, the velocity of recoil at any point can be calculated by dividing the distance between the vibrations at that point by the time occupied by a vibration :—

RECOIL of a 12 bore Shot Gun.

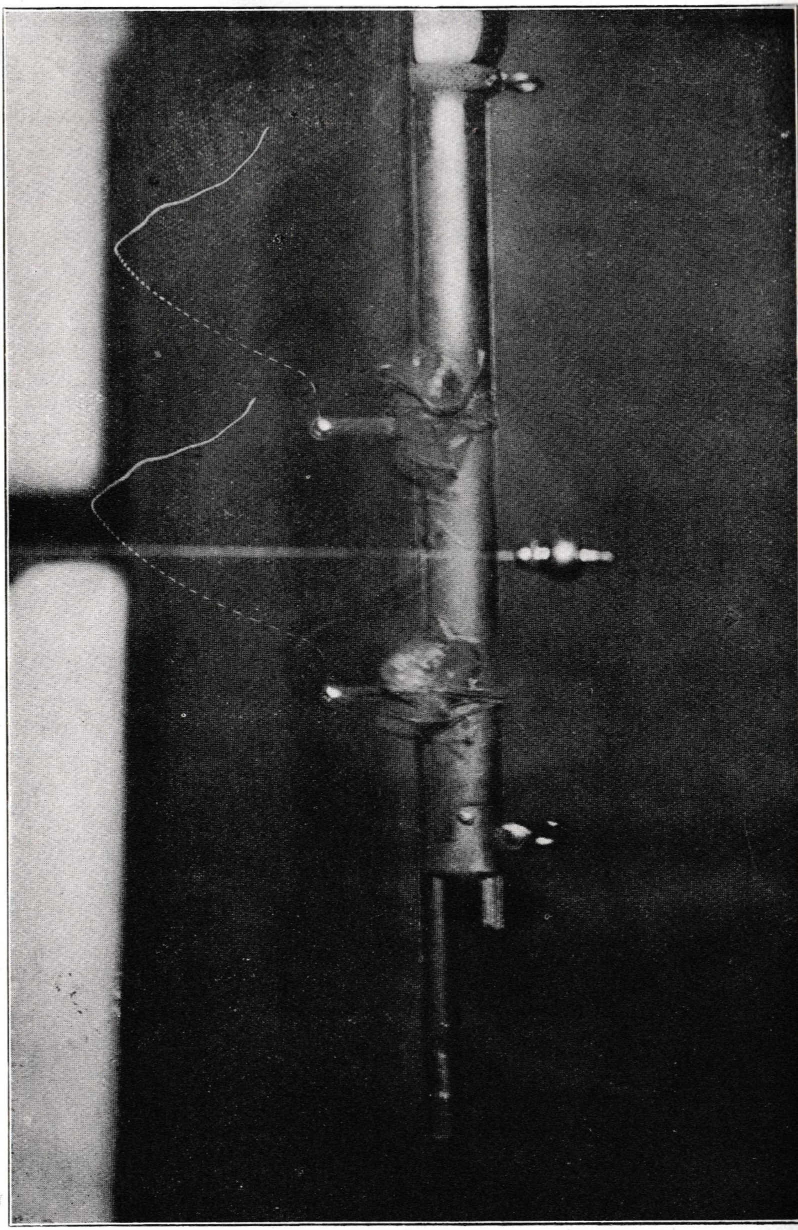
Weight.				Muzzle velocity of the shot.	Velocity of recoil.	Energy of recoil.
Of the gun.	Of the shot.	Of the wads.	Of the smokeless powder.			
lb. oz.	oz.	grs.	grs.	f.s.	f.s.	ft.-lb.
7 2½	1·37	41·66	49·4	1181	16·8	31·4

Examining expression (3) we see that the energy of recoil varies as the weight of the recoiling parts, but also as the square of the maximum recoil velocity.

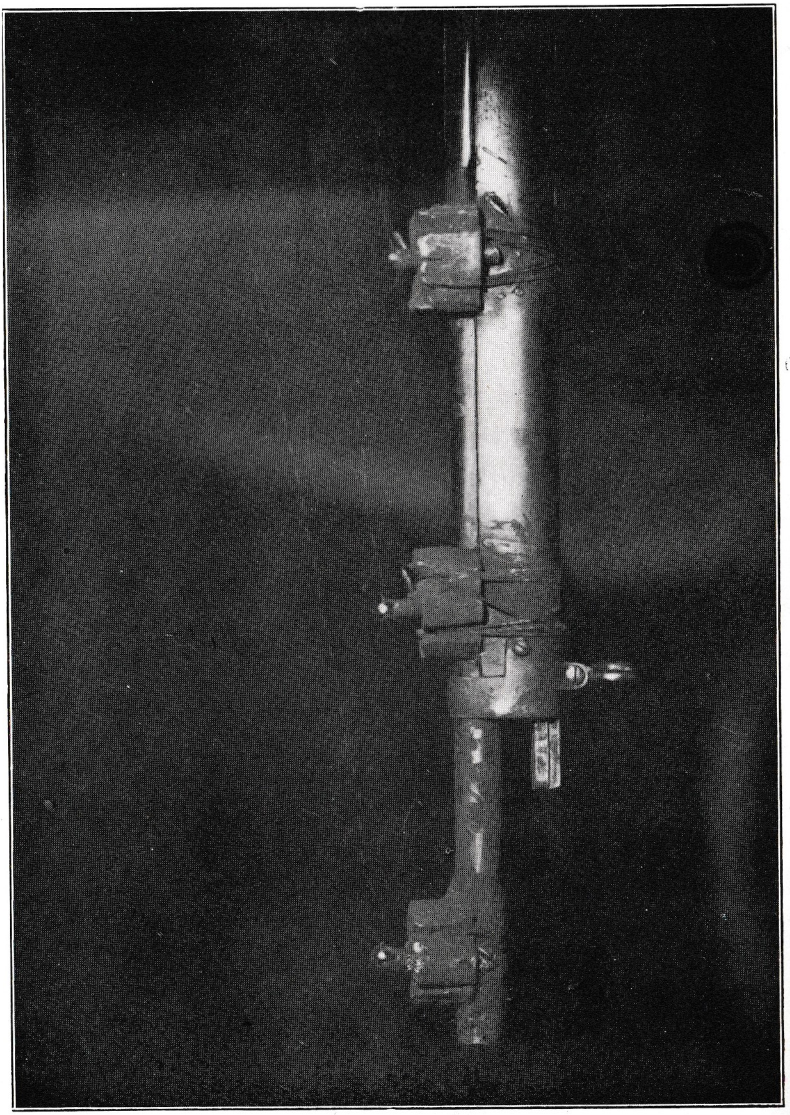
But in equation (2) the greater the value of W the less the value of V.

Hence for the same muzzle velocity, the heavier rifle will have less recoil energy. For example, the weight of Lee-Enfield short rifle with bayonet is given as 9·19 lb. as against 8·15 lb. without. This reduces U to 8·8 f.s., and the recoil energy to about 11·3 foot lbs.

In recoil operated automatic arms although the energy of recoil may be considerably heavier than that of a similar non-automatic weapon; yet the kick experienced will be less severe as it will partake more of the nature of a push, for instead of the recoil being communicated at once to the firer, the energy of recoil is employed in compressing springs, which give out the energy again when returning the barrel and breech bolt to the firing position.



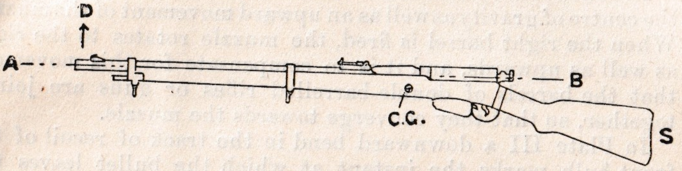
Reproduction of Untouched Photograph of the Track of Recoil of a Lee-Metford Rifle, fired with Mk. II Cordite Ammunition by a good Shot, kneeling. Each dash or space in the track represents an interval of $\frac{1}{500}$ second.



Reproduction of Untouched Photograph of the Track of Recoil of a Lee-Metford Rifle, suspended by long wires; fired with Mk. II Cordite Ammunition. Each dash or space in the track represents an interval of $\frac{1}{500}$ second.

So far the backward motion or the recoil of the rifle only has been dealt with, we will now turn to the upward motion of the muzzle. (2) Upward movement of the muzzle.

Fig. 6.



In Fig. 6 it will be seen that CG the centre of gravity of the rifle, and S the point where the backward motion of recoil is resisted by the firer's shoulder, are both below AB the line along which the gas tends to force back the barrel. The effect of this force acting along AB is to drive the rifle back and to make it revolve, so that the muzzle ascends in the direction D. If CG and S were situated on the line AB the rifle would have no tendency to revolve as it recoiled.

Plates II and III were taken by Major C. F. Close, R.E., in the following manner. Round silver studs or silvered glass bulbs were attached to the rifle, and a fenestrated cardboard disc was rotated at a known speed in front of a small arc light, so that the light was cut off from the bulbs at known intervals of time. The disc used had 60 equal sectors, 30 open and 30 closed. It was rotated by a small motor worked by four Grove cells, and completed 1,000 revolutions in times varying from 110 to 125 seconds. The disc thus gave exposures of about $\frac{1}{500}$ of a second. The luminous image of the arc light reflected from the bulbs, was then photographed, the photographic plate being arranged parallel to the axis of the rifle. It will be seen that the luminous image, reflected from the bulbs, is photographed as a series of bright dashes. Each dash represents the path of the image for $\frac{1}{500}$ of a second while each dark interval also represents $\frac{1}{500}$ of a second, while the light is cut off by the cardboard disc.

The rifle was fired in the following manner. The trigger was held back by springs fixed to the butt, and was then pulled forward by a string tightly secured to the lower band swivel; this string was burnt and the rifle was thus fired without affecting the true velocity of recoil.

In Plate II the rifle is fired from the shoulder by a good shot kneeling; for the first half-inch the track is but slightly upwards, until the clothes and flesh of the firer are compressed, and the backward motion is largely checked by the weight of the firer's body. The rifle then rotates upwards, about a point on the firer's shoulder as a centre, until checked by gravity and the firer's arms, when it descends again. As the velocity is checked the dashes become closer and closer until they form a continuous line. The bullet leaves the muzzle after the rifle

has recoiled about $\frac{1}{10}$ of an inch, which is considerably before the upward motion of the muzzle has become pronounced, but the upward motion of the barrel begins as soon as the powder gas begins to make the barrel recoil.

In double-barrel rifles there is a lateral rotation of the rifle about the centre of gravity as well as an upward movement of the muzzle. When the right barrel is fired, the muzzle rotates to the right as well as upwards, and it is to compensate for this movement that the barrels of double-barrelled rifles or guns are joined together, so that they converge towards the muzzle.

In Plate III a downward bend in the track of recoil of the front bulb marks the instant at which the bullet leaves the muzzle. The tracks of recoil of the three bulbs are wavy; these represent the major vibrations of the barrel. In this plate and others of a similar nature, the deviations from the mean of the front track are greatest, and the deviations of the track of each bulb grows smaller in succession as the bulbs are situated further to the rear and apparently cease about 10 or 12 inches from the muzzle.

(3) Vibrations of the barrel.

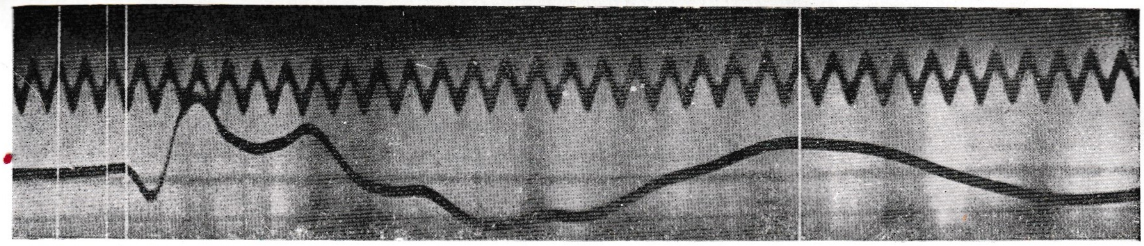
When a rifle is fired, the explosion of the charge causes a pressure often amounting to 16 tons or more per square inch acting along the line A B, Fig. 6, above the centre of gravity of the rifle; this tends to suddenly force the body and barrel to the rear. These components form an unsymmetrical mass attached to the stock, and are caused to vibrate by the shock to which they are subjected. These vibrations are both in the vertical and horizontal plane, so that the resulting motion of the muzzle is in the form of an ellipse, of which generally speaking the longer axis is approximately vertical.

The vibrations of the barrel are also partly due to the friction between the bullet and the barrel. This is known from the fact that, although the velocity of the bullet does not differ when fired from a dry barrel, and when fired from one which is slightly oily, yet with the Lee-Enfield rifle the mean point of impact is decidedly higher with the oily barrel.

The vibrations of rifle barrels have been studied by means of instantaneous photography, by Professors C. Cranz and K. R. Koch, and the Figures in Plate IV, and information concerning them, have been taken from their work entitled "Untersuchungen uber die Vibration des Gewehrlaufs," which work was published by the Krieg Bayerischen Akademie der Wissenschaften, who have courteously granted permission to reproduce them.

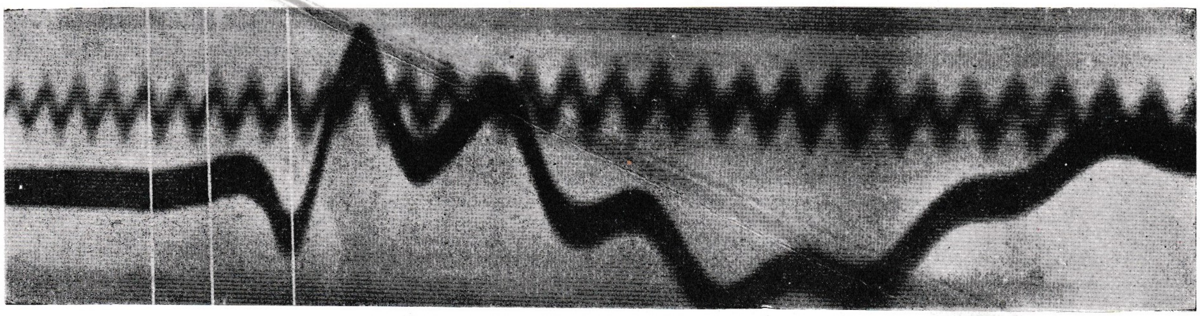
The vibrations were measured as follows:—

A piece of wire, W, Fig. 7, is attached to the barrel of the rifle at the point at which the vibration is to be measured, so that the horizontal portion of the wire crossed a brightly lighted slit, S. The magnified image of this slit is thrown on a photographic plate which is in rapid motion from side to side at the instant of firing. Now, if the barrel and wire remain steady, the latter will be represented on the photographic plate by a



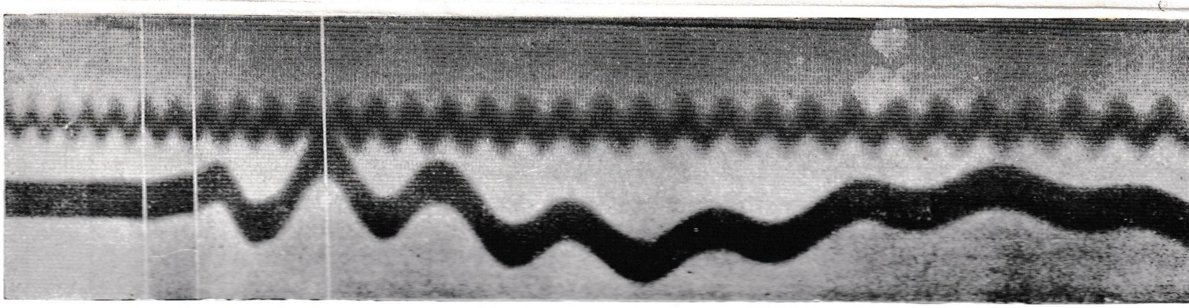
β γ

FIG. 1.—Curve of vibration of a point $\frac{3}{5}$ inch from the muzzle of German Mauser, 1871 pattern. Full charge.



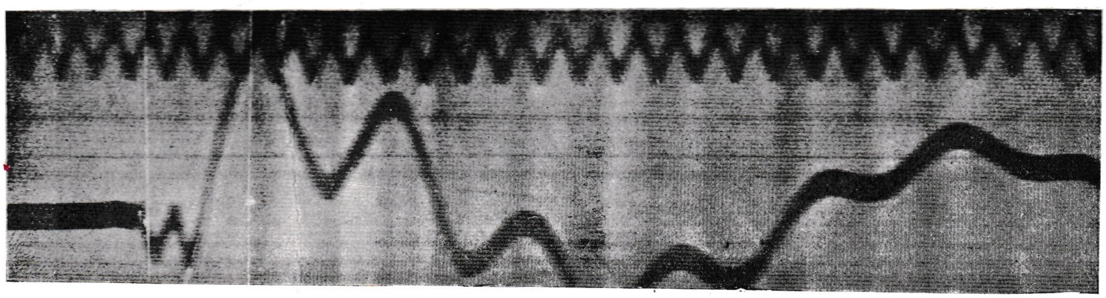
α β γ

FIG. 2.—Ditto. Half charge.



α β γ

FIG. 3.—Ditto. Quarter charge.



γ γ′

FIG. 4.—Curve of vibration of a point close to the muzzle of the German, 1898 pattern rifle. The rifle was clamped in cork. Spark γ′ when the bullet arrived at $4\frac{1}{2}$ metres from the muzzle.

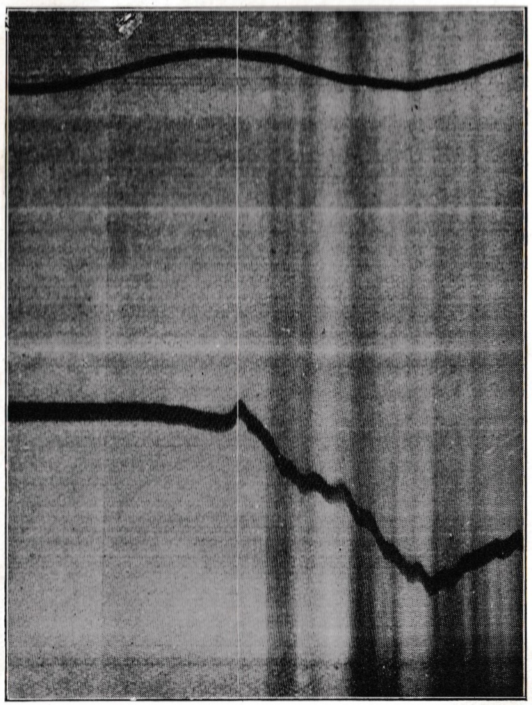
[To face p. 212.

(4148)

BARREL VIBRATIONS WITH ·303 SHORT RIFLE, MARK I.

A

e

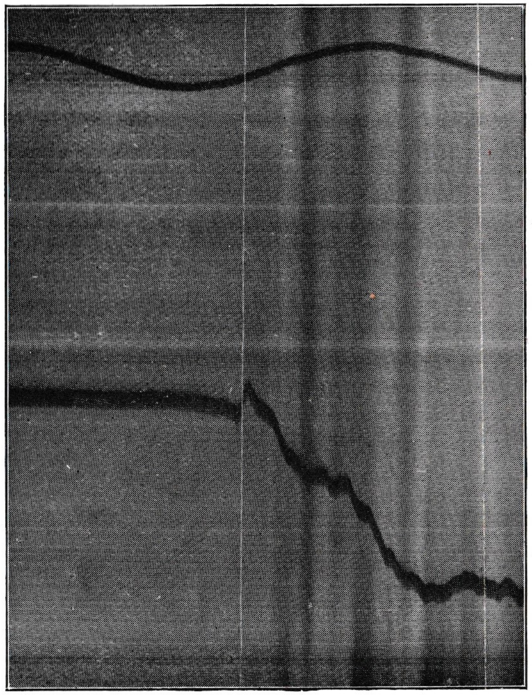


Observed velocity f/s. 2360

Point of Impact at 100 ft. 2·4 ins.

B

e



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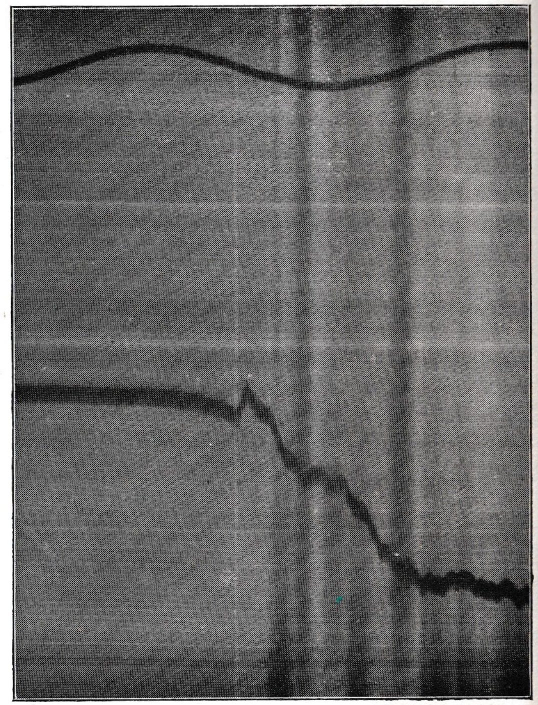
3·45 ins.

C

e



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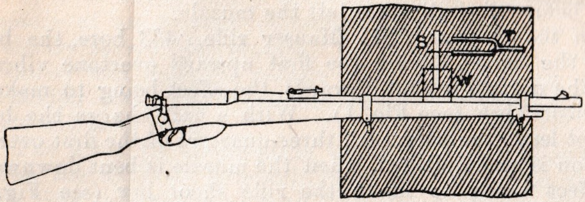
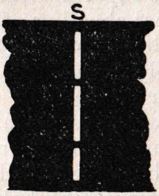
4·3 ins. low.

The white vertical line marked "e" indicates the point of exit of the bullet in each case.

Fig. 7.





horizontal black line, but if the vibration of the barrel causes the wire to move up and down, then instead of a straight black line we shall get an undulating black line, as shown in the lower half of the figures in Plate IV.

To measure the time occupied by these vibrations of the barrel a second wire, attached to a tuning fork, T, which makes a complete vibration every ·0023 second, is placed in front of the illuminated slit. The regular up-and-down motion of this wire produces the black zig-zag line shown in the upper half of the figures.

To mark the exact point at which the bullet leaves the muzzle, it is made to cut an electric wire as soon as its base is clear of the muzzle, thus causing an electric spark, which appears as a bright dot marked γ in the figures. The vertical line α in some of the figures marks the beginning of the impact of the striker, and β the instant of the explosion of the charge, the small vibrations between α and β are therefore caused by the impact of the striker.

The general results established are as follows:—

1. The rifle barrel is subject to two sets of vibrations in the vertical and horizontal plane, viz., a fundamental note caused by the vibration of the whole length of the barrel, and an overtone, or octave note, caused by the division of the barrel into vibrating sections, with nodes between them, where the barrel is still. In Fig. 4 the line γ' cuts the top of the first fundamental vibration, while the bottom of it is just out of the plate. The smaller vibrations in the curve are the overtone vibrations.

2. As affecting the shooting, the overtone vibrations are the more important, because the fundamental vibration has hardly begun before the bullet has left the muzzle.

3. In the German 1871 Mauser rifle, ·433 bore, the bullet leaves the barrel during the first upward overtone vibration when the muzzle is bent upwards, the effect being to make the rifle shoot high (see Fig. 1). With a half charge the bullet does not leave the barrel till three-quarters of the first overtone vibration is accomplished, when the muzzle is bent downwards, the effect being to make the rifle shoot low (see Fig. 2). With a quarter charge the bullet does not leave the muzzle till after one and a quarter overtone vibrations, when the muzzle is again bent upwards, the effect being to make the rifle shoot high (see Fig. 3).

These three experimental results are completely in accordance with the actual shooting of the rifle.

4. It has been found by experiment that whether the rifle be held firmly in a fixed rest, or laid on supports so as to imitate as far as possible the manner in which it is held by a skilled rifleman, the vibrations of the barrel on firing do not differ in nature or direction, though they may differ in extent.

5. It will be noticed in Figs. 1, 2, 3, representing the vibrations due to firing full, half, and quarter charges from the 1871 pattern Mauser, that the smaller the charge, and consequently the less the velocity of the bullet, the greater is the number of vibrations the barrel has made before the bullet issues from the muzzle. Also in Figs. 4 and 5 of the German Mauser, pattern 1898, and the Spanish Mauser, with muzzle velocities of 2,034 f.s. and 2,288 f.s. respectively, the bullets leave the muzzle while the vibrations are still very small. It may be assumed, therefore, that the improved accuracy of modern small bore rifles is partly due to their high initial velocity, which enables the bullet to leave the barrel before the vibrations have caused much disturbance of the muzzle.

The Lee-Enfield rifle barrel vibrates in such a manner as to reduce the differences in height between the points of mean impact of ammunition with different velocities. For example, a Lee-Enfield rifle fired with ammunition giving 2,235 f.s. velocity, shoots 12 inches lower at 200 yards than with ammunition giving 2,000 f.s. velocity. At 390 yards range the points of impact with both classes of ammunition are at the same height. At 1,000 yards the 2,235 f.s. ammunition shoots 7 feet higher than the other. We see, therefore, that the bullets of the high velocity ammunition leave the barrel when the muzzle is at a much lower point in its curve of vibration, and therefore shoot low at 200 yards, but their trajectory being flatter than that of the 2,000 f.s. ammunition, it crosses the trajectory of the latter at 390 yards range, and keeps above it at all other ranges.

In designing a new rifle endeavour should be made to so arrange the length of the barrel, the strength and weight of

the parts, and the method by which the recoil of the barrel and body is communicated to the stock, so that the barrel is in the middle of an upward vibration when a bullet with normal velocity leaves the muzzle; for then a bullet with higher velocity will leave the muzzle when it is pointing lower; and a similar compensation to that which occurs in the Lee-Enfield rifle will take place.

The 2,235 f.s. ammunition would have shot 4 inches higher than the 2,000 f.s. ammunition at 200 yards had the jump of the rifle been the same with both classes of ammunition. The lower jump, therefore, caused the 2,235 f.s. ammunition to shoot 1 foot 4 inches lower than it should have at 200 yards. At 1,000 yards the effect of the negative jump is 1 foot 4 inches $\times$ 5 = 6 feet 8 inches. This, added to the 7 feet, which is the height of impact of the 2,235 f.s. ammunition above that of the 2,000 f.s. ammunition at 1,000 yards, gives 13 feet 8 inches as the total difference in the heights of the points of mean impact which would have occurred had the vibration of the barrel and the angles of departure been the same with the two classes of ammunition. Hence we see that the vibrations of the barrel completely compensated for a difference of 235 f.s. in the velocity of the two lots of ammunition at 390 yards range, and at 1,000 yards reduced the difference between the heights of the points of mean impact from 13 feet 8 inches to 7 feet.

Plate V, A, B, and C, shows the result of recent experiments at Enfield with the ·303 short rifle, Mark I, and a similar apparatus to that described above.

These photographs show that the higher velocity bullet leaves the muzzle at an earlier point on the vibration curve, and that if the point of exit is lower on the curve, the point of impact is lower although the velocity may be higher.

Figs. 6 and 7, Plate IV, represent the horizontal vibrations of the barrel; these were measured in the same manner as before, the apparatus being erected vertically instead of horizontally.

The body of the rifle, being cut away on the right side to enable the cartridge to be ejected, is unsymmetrical, and weaker on the right side than on the left; this gives rise to lateral vibrations, which cause the rifle to shoot to the right or left. Also, the bolt handle projecting to the right is unsymmetrical, and causes lateral vibrations. Cutting off the bolt handle of the Lee-Enfield rifle makes the rifle shoot ·46 inch to the right at 100 feet. This is the result one would anticipate, for cutting off the bolt lever throws the centre of gravity of the rifle more to the left, and the further it is to the left the greater the tendency of the rifle to revolve round the centre of gravity, with the muzzle travelling to the right.

In Messrs. Cranz's and Kock's experiments it was found that a Mauser rifle with a right-hand body and bolt, shot to the right and *vice versâ*. The ordinary right-hand Lee-Enfield rifle however, shoots to the left, necessitating the foresight being placed ·02 inches to the left to correct the shooting.

When Morris tube cartridges, or the small cartridges used with Molyneux adapters, are fired from a Lee-Enfield rifle, they cause but trifling vibrations, and do not need this lateral displacement of the foresight, therefore these cartridges shoot to the right.

Black powder ·303 cartridges having a velocity of 1,850 f.s., produce different lateral vibrations from cordite cartridges, when fired in the magazine Lee-Enfield rifle, the body and bolt of which is unsymmetrical. At 100 feet range the black powder shoots $1\frac{3}{8}$ inches to the right of cordite; but in the symmetrical Martini-Enfield rifle the shooting of these two powders does not differ in direction.

Any unevenness in the bearing between the lugs on the bolt, and their seatings in the body, influence the lateral vibrations. In the Lee-Enfield rifle, if the left lug takes the greatest strain on firing, the rifle shoots to the right and *vice versâ.* It is important therefore that rifles should be used with their own bolts, the lugs of which have been made to take an even bearing by the proof charge.

On firing a rifle with the bayonet fixed, the weight of the latter impedes the vibrations.

In Fig. 6 without the bayonet, the bullet leaves the muzzle, when the latter has vibrated nearly twice as much as it has in Fig. 7 with the bayonet fixed. The Lee-Enfield rifle with bayonet fixed, shoots to the right, as the full allowance given by placing the foresight ·02 left is not required, on account of the vibrations having been checked.

Fixing bayonets also affects the vertical vibrations, and usually makes a rifle shoot low.

From what has been said with regard to the movements of the rifle, it will be seen that "*jump*" is the combined result of the upward rotation of the rifle about its centre of gravity and the vibrations of the muzzle of the barrel.

The method of practically determining *the jump* is illustrated by an example in Chapter V, page 239.

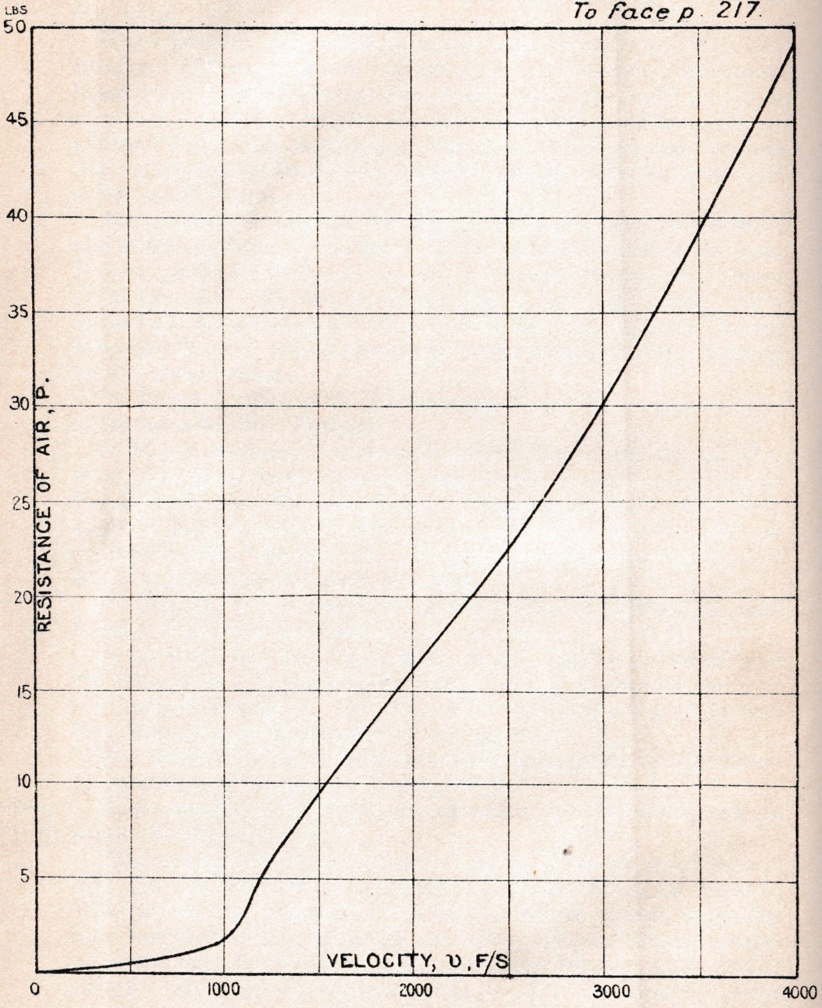
(4) Twisting movement of the rifle.

There remains the twisting movement of the rifle about its axis to be mentioned.

This movement does not appear to be of much importance; still, there is no doubt a slight rotation of the rifle in an opposite direction to the projectile; for as the bullet passes down the bore and is forced to rotate by the rifling, the bullet endeavours to rotate the rifle by pressing against the driving edges of the rifling. Its want of success is due to the fact that it is only $\frac{1}{300}$ the weight of the rifle, and has a smaller radius of gyration. The vibrations of the barrel are probably affected to a small extent, by this reaction between the bullet and the rifling.

PLATE VI. PART II.

To face p. 217.



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CHAPTER IV.

Exterior Ballistics—The Resistance of the Air.

We now come to the consideration of the motion of the bullet after it has left the bore of the rifle with a certain muzzle velocity.*

The forces acting on the bullet are then the resistance of the air and gravity.

It is found as the result of experiment, that there is no simple general law connecting the resistance of the air to a projectile with the velocity at which it is moving, although at low velocities (say below 800 f/s) and at very high velocities (above 3,000 f/s) the resistance varies approximately as the square of the velocity.

The method generally adopted is to deduce from experiments the resistance of the air to a standard projectile at various velocities.

Then, as the resistance is found to be proportional to the cross section of the projectile, and consequently to the square of its diameter, if the standard projectile be 1 inch in diameter, and the resistance to it at velocity v f/s be p lbs., the resistance R to a similar projectile d inches in diameter at velocity v f/s will be given by

$$R = d^2 p \text{ lbs.}$$

Plate VI shows the corresponding values of p and v plotted in the form of a curve, for a standard projectile with a cylindrical body 1 inch diameter and with an ogival head struck with a radius of two calibres, for velocities from 100 f/s to 4,000 f/s.

This curve represents the results of experiments carried out under the superintendence of the Ordnance Committee (now the Ordnance Board) during the years 1902–6, with the object of revising the Bashforth Ballistic Tables and extending them to higher velocities.

The tables given at the end of this book are all based on this $p\,v$ curve.

The construction for an ogival head struck with a radius of two calibres is shown in Fig. 8.

Let ABDE be a longitudinal section through the centre of the cylindrical body of a projectile d inches in diameter.

Produce AB both ways and make

$$AB^1 = A^1B = AB = d.$$

* The blast of the gases of the charge causes the velocity of the bullet to increase slightly after it has actually left the muzzle, but for our purposes this effect may be neglected in ballistic calculations, as the muzzle velocities dealt with are, as a rule, calculated back from observed velocities at some distance from the muzzle, and so are, in a sense, nominal.

With centres A^1, B^1 and radii $A^1A = B^1B = 2d$, describe arcs cutting at C.

The head ACB of the projectile is then said to be an ogive struck with a radius of two calibres.

Variations in the shape of head will affect the resistance of the air, and to allow for this a coefficient κ, called the coefficient of shape, is introduced so that

$$R = \kappa d^2 p.$$

The larger the radius of the ogive the less will the value of κ be. For the standard projectile on which our Ballistic Tables are based, we have $\kappa = 1$, and an approximate value of κ for other ogival heads is given by the formula

$$\kappa = \frac{2}{n} \sqrt{\frac{4n-1}{7}}$$

where n is the radius of the ogive in calibres.

Fig. A, Plate VII is drawn from a photograph of a service ·303 bullet in flight, taken by Mr. C. V. Boys; the air waves diverging from the head and base, and the trail of eddies in the wake of the bullet are very clearly shown, and resemble closely the waves set up on the surface of water by a swift steamer.

B is from a similar photograph of a pointed bullet. The front wave is seen to be more acute and closer to the point than in A. The wad will be noticed following the bullet.

Behind the bullet in flight, a partial vacuum and a trail of air eddies are formed. The vacuum retards the bullet, as the base is deprived of the support of the ordinary atmospheric pressure of 15 lbs. per square inch. To prevent this vacuum forming, and to enable the compressed air at the front of the bullet to flow away easily, Messrs. Krnka and Hebler produced a torpedo-shaped bullet with a cylindrical hole down the centre, the rear end fitted into a sabot of papier mâché. A very high velocity was claimed for this bullet on account of the diminished air resistance, but it has not proved a practical success on account of its inaccuracy.

Variations in the steadiness of the projectile due to differences in centreing affect the resistance of the air. To allow for this a coefficient σ, called the coefficient of shape, is introduced, so that

$$R = \kappa \sigma d^2 p.$$

The resistance of the air is also proportional to its density.

The density depends on the barometric pressure, the temperature, and the amount of moisture the air contains.

The lower the barometer, the higher the temperature, and the more moisture in suspension, the less will be the density of the air, and consequently, the less the air resistance.

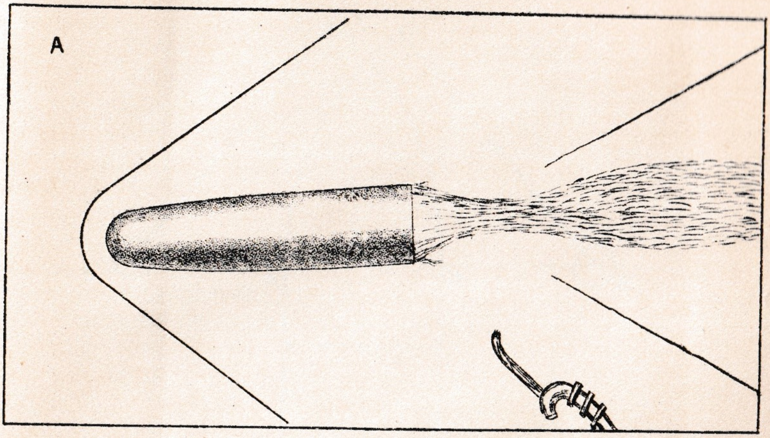
Our values of p are calculated for a certain standard density of the air* representing approximately normal atmospheric conditions.

* 534·22 grains per cubic foot, being the weight of a cubic foot of air at 30-inch pressure, 60° F., and $\frac{2}{3}$ saturated with moisture.

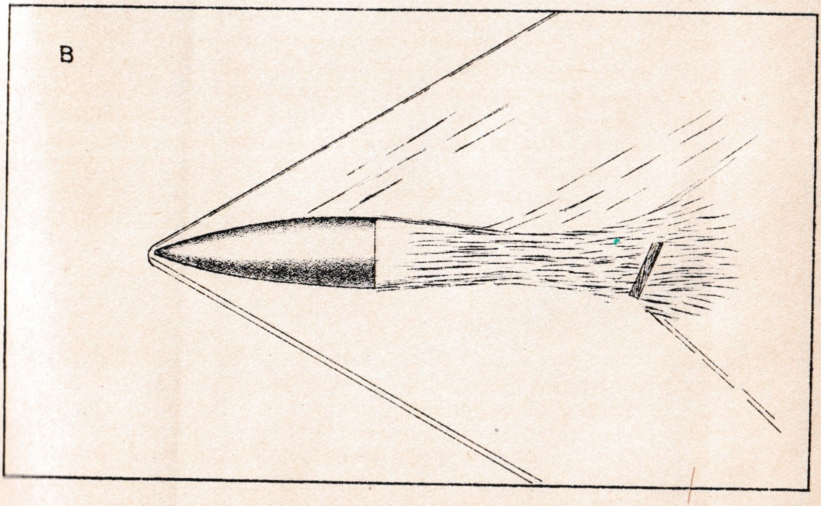
To Face p. 218.

PLATE VII. PART II.

A



B



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To face p. 218.

FIG. 8.

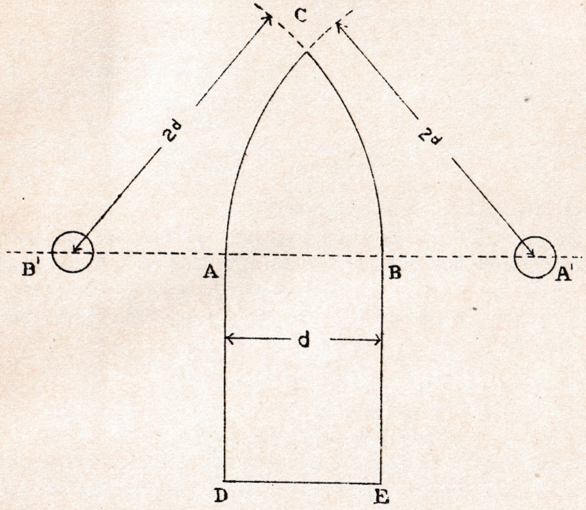
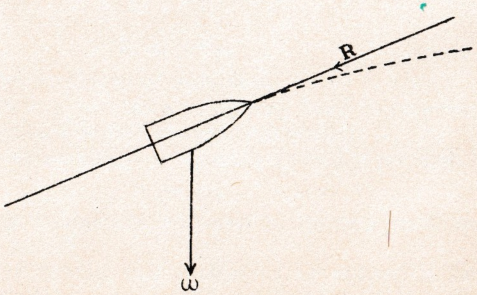


FIG. 9.



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To allow for variations from the standard occurring in actual practice we introduce a coefficient τ, the coefficient of tenuity, defined by

$$\tau = \frac{\delta}{\Delta} = \frac{w}{534{\cdot}22},$$

where δ = density of air at time under consideration,
Δ = standard density of air,
w = weight of a cubic foot of air at the time under consideration.

Introducing the coefficient τ we have as our complete expression for the resistance of the air

$$R = \kappa\sigma\tau d^2 p.$$

The values of τ for pressures of 26 to 31 inches, and temperatures of 0 to 100° F., for a standard degree of humidity ($\frac{2}{3}$ saturated) are given in Table G.

The value of τ is also approximately given by

$$\tau = \frac{B}{30}\left(\frac{1{,}000}{1{,}000 + 2\,(T - 60)}\right),$$

where B = reading of barometer,
T = reading of thermometer.

The density of the air and consequently the value of τ decreases as the height above sea-level increases.

The barometer falls approximately 1 inch for every 1,000 feet rise, while the temperature falls at the rate of about 1° F. for every 300 feet, so that $\tau = 1$ at sea-level becomes about $\tau = 0{\cdot}919$ at 3,000 feet altitude (*see* Table G).

As a guide to the effect of altitude on shooting, we may take the approximation that 1 per cent. decrease or increase in τ will cause a bullet to range about 1 per cent. more or less, and this will require to be corrected by about 1 per cent. decrease or increase of elevation. Thus a rifle sighted for sea-level might be expected to shoot about 110 yards over at 1,000 yards range at an altitude of 4,000 feet.

For convenience we may write

$$n = \kappa\sigma\tau,$$

so that

$$R = nd^2 p,$$

and n is called the *coefficient of reduction.*

The coefficients κ, σ are, as a rule, very hard to separate and are usually determined together experimentally.

Under normal atmospheric conditions ($\tau = 1$), we then have

$$n = \kappa\sigma,$$

and this value is frequently referred to as the coefficient of reduction of the bullet.

Thus, with our tables, the coefficient of reduction for the 303, Mark VI, bullet is about 0·76, while that of the sharper pointed German S/05 bullet is about 0·56, and the French D/05, 0·53.

Gravity, or "Terrestrial Gravitation," is the force attracting every body in a straight line towards the centre of the earth The acceleration due to gravity has been referred to on p. 196 as a familiar illustration of a constant acceleration.

This acceleration is always denoted by g, and is approximately 32 f/s per second.*

The relation between h, the height fallen in feet from rest, and the time, t seconds, is given in vacuo by the well-known equation

$$h = \frac{1}{2} g t^2 \quad \text{.......................(1).}$$

A bullet being a small heavy body does not experience much resistance when falling through the air for a short time, so that for practical purposes equation (1) may be taken to give the height fallen in air.

Thus in 1 second a body falls 16 feet, in two seconds 64 feet and so on.

If we now consider the forces acting on the bullet we have (Fig. 9) the resistance of the air R acting in a contrary direction to the direction of motion, and w the weight of the bullet acting vertically downwards we see that the resultant force must always tend to lower the bullet and so make it describe a trajectory concave to the horizontal line drawn through the origin of this trajectory.

---

* The value of g varies slightly with the latitude, it is smaller at the equator, which is further from the centre of the earth, than it is in the Arctic region. In the latitude of London $g = 32{\cdot}2$ approximately.

CHAPTER V.

Ballistic Tables.

In Chapter IV we took as our expression for the resistance of the air

$$R = nd^2p \text{ lbs.},$$

where n is the coefficient of reduction of the projectile, and d its diameter in inches, while p is defined on p. 217.

On the basis of the values of p shown by the curve in Plate VI, certain functions of the velocity connected with the time of flight, range, and inclination of the projectile are calculated and incorporated in the form of Ballistic Tables, by means of which we can conveniently solve a number of problems in exterior ballistics.

Ballistic Table H.

Suppose the projectile is flying horizontally, the effect of gravity being left out of account; the motion is retarded continually by the resistance of the air; and if Δv denotes the loss of velocity, in f/s, in a short interval of time of Δt seconds, then the *average* retardation r is given in f/s per second by

$$r = \frac{\Delta v}{\Delta t}.$$

But by Newton's Second Law of Motion, if the shot weighs w lbs., and the resistance of the air is R lbs. then

$$\frac{r}{g} = \frac{R}{w}, \text{ or } \frac{w}{g} = \frac{R}{r}.$$

Putting—

$$R = nd^2p,$$

where p refers to the *average* value in the interval of time Δt, then

$$\frac{\Delta v}{\Delta t} = \frac{R}{w} g = \frac{nd^2pg}{w},$$

or

$$\Delta t = \frac{w}{nd^2} \frac{\Delta v}{pg}.$$

The quantity $\frac{w}{nd^2}$ is called the *ballistic coefficient* of the projectile, and denoted by the letter C, so that

$$C = \frac{w}{nd^2},$$

and then

$$\frac{\Delta t}{C} = \frac{\Delta v}{pg}.$$

Since p is the same for all projectiles, and g is a constant, then, if we take a constant drop in velocity (say, of 10 f/s, or $\Delta v = 10$),

$$\frac{\Delta v}{pg}$$

is a number *which is the same for all projectiles;* it is denoted by ΔT, and

$$\Delta T = \frac{\Delta v}{pg},$$

and this is the time in seconds it takes the projectile, for which $C = 1$, to drop from velocity

$$v + \frac{1}{2}\Delta v \text{ to } v - \frac{1}{2}\Delta v \text{ f/s},$$

if v denotes the mean velocity in the interval.

The number ΔT is calculated numerically once for all. The sum of the values of ΔT is made, and entered into a column denoted by T_v, as in Table H, so that $T_V - T_v$ is the time taken by the shot, whose ballistic coefficient C is unity, whilst its velocity falls from V to v f/s.

If the value of C be not unity, then since

$$\frac{\Delta t}{C} = \frac{\Delta T}{1} = \frac{\Delta v}{pg},$$

$$\frac{\Delta t}{C} = \Delta T,$$

$$\frac{t}{C} = T_V - T_v \text{ ....(1).}$$

For example, suppose it is required to find the time it would take the velocity of a projectile, for which $C = 1$, to fall from 2,000 f/s to 1,000 f/s.

Looking out the values of T_v in Table H corresponding to 2,000 f/s and 1,000 f/s we have

$$T_{2000} = 110{\cdot}272$$
$$T_{1000} = 105{\cdot}560$$

$$T_{2000} - T_{1000} = \overline{\quad 4{\cdot}712 \quad} = \frac{t}{C},$$

and as $C = 1$,

$$t = 4{\cdot}712 \text{ seconds.}$$

Now for a projectile whose ballistic coefficient is 5,

$$\frac{t}{C} = 4{\cdot}712 \text{ as before,}$$

but as $C = 5$

$$t = 5 \times 4{\cdot}712 = 23{\cdot}56 \text{ seconds.}$$

The ballistic coefficient

$$C = \frac{w}{nd^2}$$

may be looked upon as representing the capability of a projectile for overcoming the resistance of the air, and so maintaining its velocity.

The value of d should correspond to the effective area of the cross section of the bullet exposed to the resistance of the air.

For rifles the effective diameter is generally taken as the calibre + the depth of one groove so as to get an approximate mean value.

Thus with ·303 L.E. rifle

$$\begin{aligned} \text{calibre} &= 0{\cdot}303 \text{ inches} \\ \text{depth of groove} &= 0{\cdot}0065 \text{ inches} \\ \hline d &= 0{\cdot}31 \text{ inches nearly.} \end{aligned}$$

This agrees with the measured diameter of fired bullets, and will be the value taken for d with this bullet in subsequent work.

A table of particulars of some modern military rifle bullets is given below. These data will be referred to in subsequent examples.

PARTICULARS OF BULLETS.

Bullet.	Effective diameter, inches.	Weight, grs.	* w/d^2.	n.	C.	Muzzle velocity, f/s.
·303 Mk. VI	0·31	215	0·320	0·76	0·421	2,060
French D/05	0·32	198	0·276	0·53	0·521	2,380
German S/05	0·32	154	0·215	0·56	0·384	2,820
U.S.A. Model/06	0·30	150	0·238	0·56	0·425	2,700
Ross-Eley	0·28	150	0·273	0·51	0·535	2,900

BALLISTIC TABLE K.

The T_v Table gives us a relation between time and velocity, from this a relation between space and velocity can further be deduced.

Let Δs denote the number of feet traversed by the projectile in the short time Δt, then

$$\Delta s = v\Delta t,$$

where v denotes the mean velocity in the interval of time Δt.

But we have

$$\Delta t = \text{C}\Delta\text{T},$$

$$\therefore \Delta s = v\,(\text{C}\Delta\text{T}),$$

and putting $$\Delta s = \text{C}\Delta\text{S},$$

we have $$\Delta\text{S} = v\Delta\text{T}.$$

* Frequently termed the "sectional density of the bullet."

Whence ΔS can be calculated by multiplying ΔT by the corresponding mean velocity in the intervals.

Then, as before, the sum of the values of ΔS is entered in Table K in a column and denoted by S_v, and we have

$$\frac{S}{C} = S_V - S_v \dots\dots\dots\dots\dots\dots\dots\dots (2),$$

where S denotes the space in feet traversed by a projectile whose ballistic coefficient is C, while the velocity falls from V to v f/s.

Thus taking the projectile with $C = 5$, we found on p. 222, that it would take 23·56 seconds for its velocity to drop from 2,000 f/s to 1,000 f/s, suppose it is now required to find how far it would have travelled while the velocity fell from 2,000 f/s to 1,000 f/s.

Looking out the values of S_v in Table K, corresponding to 2,000 f/s and 1,000 f/s, we have

$$S_{2000} = 41435{\cdot}7$$
$$S_{1000} = 35207{\cdot}6$$
$$S_{2000} - S_{1000} = \overline{6228{\cdot}1} = \frac{S}{C}$$

and with $$C = 5,$$
$$S = 31140{\cdot}5 \text{ feet.}$$

Some typical examples of the use of the T_v and S_v Tables will now be given. To avoid confusion at this point the summary of the symbols and formulæ employed, given on p. 242, may be consulted.

In the actual working four-figure logarithms will be sufficiently accurate, and may frequently be replaced by the slide rule.

Problem 1.—Knowing the muzzle velocity (V), and the ballistic co-efficient (C), to find the remaining velocity (v), and the time of flight (t), at a range of X feet.

We have $$S_v = S_V - \frac{X}{C},$$

whence we can find S_v and v.

Then $$t = C\,(T_V - T_v)$$

will give us t.

Example—Find the remaining velocity and time of flight at ranges of 500 and 1,000 yards of the ·303, Mark VI, bullet, fired from the S.L.E. rifle.

Here $V = 2{,}060$ f/s,

$C = 0{\cdot}421$ (*vide* p. 223).

The work may be arranged as follows :—

R yards	500	1,000
X feet...	1500	
Log. X	3·1761	
Log. C...	$\bar{1}$·6243	
Log. $\frac{X}{C}$	3·5518	
$\frac{X}{C}$	3,563	7,126
S_V	41,663·4	
S_v	38,100·4	34,537·4
v f/s	1,281	961
T_V	110·384	
T_v	108·169	104·870
$\frac{t}{C}$	2·215	5·514
Log. $\frac{t}{C}$	0·3454	0·7415
Log. t	$\bar{1}$·9697	0·3658
t second	0·933	2·321

Problem 2.—Knowing the ballistic coefficient (C) and the remaining velocity (v) at a range (X), to determine the muzzle velocity (V).

We have
$$S_V = \frac{X}{C} + S_v,$$
whence we can find S_v, and V.

Example.—A rifle bullet whose ballistic coefficient is known to be about 0·55 is stated to have a striking velocity of 1,550 f/s. at a range of 600 yards. What muzzle velocity does this imply?

Here
$$C = 0·55$$
$$X = 1,800 \text{ feet},$$
$$V = 1,550 \text{ f/s}.$$

Working by slide rule
$$S_v = 39,535·8$$
$$\frac{X}{C} = 3,272$$
$$S_V = 42,808$$
$$V = 2,375 \text{ f/s}.$$

Problem 3.—Knowing the observed velocities v_1 and v_2 of a bullet at ranges X_1 and X_2, to determine the ballistic coefficient and the coefficient of reduction.

Here we have $$\frac{X_2 - X_1}{C} = S_{v_1} - S_{v_2},$$

or $$C = \frac{X_2 - X_1}{S_{v_1} - S_{v_2}},$$

whence C can be found.

Then $$C = \frac{w}{nd^2}$$

or $$n = \frac{w}{Cd^2}$$

whence n, and if the atmospheric conditions are known we can find τ, and $\kappa\sigma$, will be given by

$$\kappa\sigma = \frac{n}{\tau}.$$

Example.—The observed velocities of a rifle bullet (w = 215 grains, d = 0·31 inch) are 2,002 f/s at a distance of 90 feet from the muzzle and 1,181 f/s at a range of 570 yards. The height of the barometer was 29·96 inches, and the temperature was 49° F. at the time of the experiment. Find the ballistic coefficient and $\kappa\sigma$.

Here
$$\begin{aligned} v_1 &= 2{,}002 \text{ f/s}, \\ v_2 &= 1{,}181 \text{ f/s}, \\ X_1 &= 90 \text{ feet}, \\ X_2 &= 1{,}710 \text{ feet}, \\ X_2 - X_1 &= 1{,}620 \text{ feet}, \\ S_{v_1} &= 41{,}443{\cdot}3 \\ S_{v_2} &= 37{,}406{\cdot}9 \\ S_{v_1} - S_{v_2} &= 4{,}036{\cdot}4 \\ \text{Log } (S_{v^1} - S_{v_2}) &= 3{\cdot}6059 \\ \text{Log } (X_2 - X_1) &= 3{\cdot}2095 \\ \text{Log } C &= \bar{1}{\cdot}6036 \\ \therefore C &= 0{\cdot}4015 \end{aligned}$$

From Table G $$\tau = 1{\cdot}024$$

and $$\frac{w}{d^2} = 0{\cdot}320,$$

$$\therefore \kappa\sigma = \frac{w}{C\tau d^2} = \frac{0{\cdot}320}{0{\cdot}4015 \times 1{\cdot}024} = 0{\cdot}779$$

Ballistic Table L.

If ϕ be the angle with reference to the horizontal and V the velocity with which a projectile is moving at some point, and θ the angle at some further point when the velocity has fallen to

HOW TO FIND THE BALLISTIC COEFFICIENT "C."

A+M March BY E. NEWITT. 11-1915

THE British ballistic tables are based upon the resistance of the air to a projectile one pound in weight, one inch in diameter, and having an ogival head of two diameters; consequently the use of these tables for nearly every computation requires that "C" be known.

When "C" is not known it can be ascertained in one of the following ways:

(a) by finding the range when muzzle velocity and angle of projection are known.

(b) by finding the angle of projection when range and velocity are known.

In both methods there are experimental errors to be considered and in trying to reconcile observed differences not only is experience needed, but a sound knowledge of the structure of the tables. There is one certainty however, *if the real angle is used with the real muzzle velocity for the real range, then the real remaining velocity is obtained by the use of the value of "C" found by* $\sin 2\phi = aC$, *and any difference from that r/v found by experiment is due to experimental error, and vice versa if you begin with r/v and work back to the angle.*

The next thing to keep clearly in mind is the effect of 1 per cent error in finding "V" and "v," as it can always be assumed that the range has been correctly measured. It is especially important to see that the range is long enough to get an angle in which one minute error and 5 foot-seconds velocity are incapable of effecting the result by ten per cent in "C" or the like.

Whoever is responsible for ascertaining "C" should be also responsible for the other data "V" and "v." It is obvious that these cannot be taken from any unreliable source such as a catalog or newspaper as they include the answer sought for.

Assume you are about to proceed by the (b) method, that is to say, to find the angle of projection when range and velocity are known, of a modern military rifle.

The first step is to equip the rifle with a backsight having a spirit level, vernier reading, and capable of fine adjustment. Such a backsight as is commonly used in long range match shooting, fixed to the butt plate so as to give a long sight radius, the shooting being done from the back position, is well adapted for the purpose. The rifle must first be zeroed, which is best done at such a short range as 12 1-2 yards, the backsight being screwed down until the bullet strikes as much below the point aimed at as the foresight is above the axis of the barrel, plus the drop of the bullet at the distance, which at such a distance is very small.

The muzzle velocity of the ammunition must now be ascertained by means of the chronograph, the mean of that of ten shots being taken. The chronograph gives instrumental velocity to which must be added, by computation, the velocity lost by the bullet in its journey between the chronograph wires. As this computation is also based on "C" it will be necessary to assume a "C" and make adjustments after the final "C" has been ascertained. A similar remark applies to the trifle which has to be added for drop when zeroing the rifle.

As the British tables are also based on a temperature of 60 degrees Fah. and 30 seconds Bar., it will save trouble and uncertainty if a day when these conditions prevail is selected for the shooting, and 1000 yards is about the best range at which to ascertain the required angle.

Included/ on page 133. 233

FIG. 10.

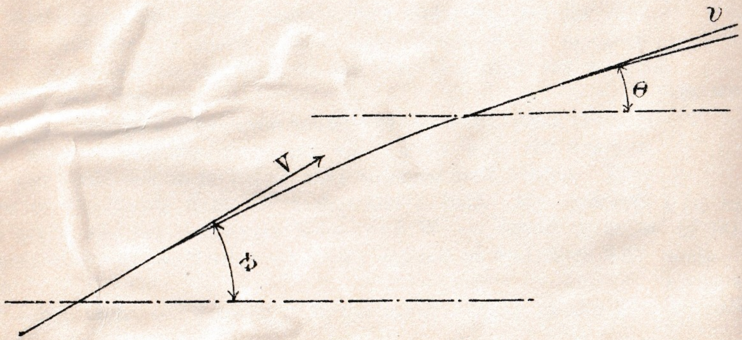
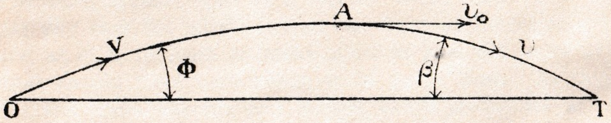


FIG. 11.



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v (figure 10), it is shown in the Text Book of Gunnery, Part II, that ϕ and θ are connected by the equation

$$\frac{\tan\phi - \tan\theta}{C} = I_V - I_v \text{ ....(3)},$$

where the function I_v is deduced from ΔT.

Let us now consider a bullet projected from O (figure 11) with a muzzle velocity V at an angle ϕ to the horizontal so that it describes a trajectory OAT, A being the highest point of the trajectory, or vertex, when the bullet is moving horizontally, and T being the point where the bullet strikes the horizontal plane O T again with striking velocity v and at an angle of descent β.

In a flat trajectory, such as we are generally dealing with in rifle fire, the vertical component of the resistance of the air is insensible, so that we may assume that the time the bullet takes in going from O to A is the same as that which it takes in going from A to T, *i.e.*, the vertex is at the point of half-time.

Let v_0 be the velocity at the vertex, and T the time of flight from O to T, then

$$\frac{T}{2} = C\,(T_V - T_{v_0}) = C\,(T_{v_0} - T_v),$$

from which v_0 can be found.

Now at A, since the bullet is travelling horizontally, $\theta = 0$ and equation (3) reduces to

$$\tan\phi = C\,(I_V - I_{v_0}) \text{................(4)},$$

whence ϕ can be found. Also at T, $\theta = -\beta$, and

$$\tan\beta = C\,(I_{v_0} - I_v) \text{................(5)},$$

whence β can be found.

(4) and (5) then give us a means of finding the angles of projection and descent if the time of flight is known or can be calculated, but a shorter and more direct method will be described later.

Ballistic Table M.

Table M is used for determining the angle of projection ϕ, necessary for a given range of X feet or R yards with a muzzle velocity V and ballistic coefficient C.

We have in direct fire, Siacci's equation (*see* Text Book of Gunnery).

$$\sin 2\phi = 2C\left(I_V - \frac{A_V - A_v}{S_V - S_v}\right) \text{................(6)},$$

where v is the remaining velocity at the range determined by

$$\frac{X}{C} = S_V - S_v$$

and A_V is Siacci's altitude function. Putting

$$2\left(I_V - \frac{A_V - A_v}{S_V - S_v}\right) = a$$

(6) becomes

$$\sin 2\phi = Ca.$$

The value of a then depends on $\frac{X}{C}$ or $\frac{R}{C}$ and V.

Table M gives us the values of a in the form of a double entry table for muzzle velocities V f/s and "reduced ranges," $\frac{R}{C}$ yards. Then for any range we look out a corresponding to the muzzle velocity and the reduced range, and multiplying this value of a by C gives us the sine of twice the angle of projection.

This will now be illustrated by examples.

Problem 4.—Knowing the ballistic coefficient (C) and the muzzle velocity (V) to find the angle of projection (ϕ) necessary for a range of R yards.

Look out a in Table M for the given V and $\frac{R}{C}$.

Then $$\sin 2\phi = Ca,$$
whence ϕ can be found.

Example.—Find ϕ for the D/05 and S/05 bullets at a range of 1,000 yards.

Taking data from page 223.

	D/05.	S/05.
V f/s	2,380	2,820
C	0·521	0·384
R yards ...	1,000	
Log R ...	3	3
Log C ...	$\bar{1}$·7168	$\bar{1}$·5843
Log $\frac{R}{C}$ ...	3·2832	3·4157
$\frac{R}{C}$	1,920	2,604
	a_{2000} = ·06143	a_{2700} = ·07231
	a_{1900} = ·05645	a_{2600} = ·06727
	100 yds. = 498	100 yds. = 504
	20 yds. = 99	4 yds. = 20
a	0·05744	0·06747
Log a	$\bar{2}$·7592	$\bar{2}$·8292
Log sin 2ϕ ...	$\bar{2}$·4760	$\bar{2}$·4135
2ϕ	1° 43′	1° 29′
ϕ	51′·5	44′·5

Problem 5.—Knowing the ballistic coefficient (C), the muzzle velocity (V), and the angle of projection (ϕ), to determine the range (R) we have

$$a = \frac{\sin 2\phi}{C},$$

and this a will be found in Table M, in the column for muzzle velocity V, under a certain value of $\frac{R}{C}$.

Then $$R = \frac{R}{C} \times C.$$

Example.—What will be the range of the D/05 and S/05 bullets with an angle of projection of 2°?

	D/05.	S/05.
V	2,380 f/s	2,820 f/s
C	0·521	0·384
ϕ	2°	2°
Log sin 2ϕ ...	$\bar{2}$·8436	$\bar{2}$·8436
Log C	$\bar{1}$·7168	$\bar{1}$·5843
Log a	$\bar{1}$·1268	$\bar{1}$·2593
a	0·1339	0·1817
	a_{3200} = 0·14112	a_{4200} = 0·18634
	a_{3100} = 0·13313	a_{4100} = 0·17738
	100 yds. = 799	100 yds. = 896
	10 yds. = 80	48 yds. = 430
$\frac{R}{C}$	3,110	4,148
Log $\frac{R}{C}$	3·4928	3·6178
Log R	3·2096	3·2021
R	1,620 yds.	1,592 yds.

Problem 6.—Knowing the ballistic coefficient (C) and the corresponding angle of projection (ϕ) for a range (R) to determine the muzzle velocity (V).

Here we know

$$a = \frac{\sin 2\phi}{C}$$

and also $$\frac{R}{C}.$$

We then find by inspection of Table M the corresponding V for these values of a and $\frac{R}{C}$.

Example.—A rifle bullet for which $C = 0{\cdot}425$ is found to require an angle of projection of 39′ for a range of 1,000 yards. What is the muzzle velocity? We have

$$a = \frac{\sin 2\phi}{C} = \frac{\sin 1^\circ\ 18'}{0{\cdot}425} = 0{\cdot}05338,$$

and $$\frac{R}{C} = 2{,}353.$$

For this value of $\frac{R}{C}$ we find that a lies between

$$a_{2870} = 0{\cdot}05368$$
$$a_{2880} = 0{\cdot}05325$$

And taking proportional parts,

$$V = 2{,}877 \text{ f/s}.$$

Problem 7.—Knowing the muzzle velocity (V), and the angle of projection (ϕ) for a range (R yards), to find the ballistic coefficient (C) and the coefficient of reduction (n).

We have

$$\frac{\sin 2\phi}{R} = \frac{Ca}{R} = a\Big/\frac{R}{C}.$$

We therefore find by inspection of Table M with muzzle velocity V for what value of $\frac{R}{C}$

$$a\Big/\frac{R}{C} = \frac{\sin 2\phi}{R}.$$

This is the correct value of $\frac{R}{C}$, and C is found from

$$C = R\Big/\frac{R}{C},$$

also $$n = \frac{w}{Cd^2}.$$

Example.—A rifle bullet (w = 150 grains, d = 0·28 inch) with a muzzle velocity of 2,900 f/s requires an angle of projection of 33′ for a range of 1,000 yards.

Find C and n.

$$\frac{\sin 2\phi}{R} = \frac{\sin 1^\circ\ 6'}{1{,}000} = 0{\cdot}0^4192.$$

Turning to Table M we find that with V = 2,900 f/s,

$\frac{R}{C}$	1,900	2,000
a	0·03633	0·03950
$a\Big/\frac{R}{C}$	0·0⁴191	0·0⁴197.

Hence $\frac{R}{C} = 1{,}916$ is about the correct value,

$$\therefore C = \frac{1{,}000}{1{,}916} = 0{\cdot}523,$$

and $$n = \frac{150}{0{\cdot}523 \times 7{,}000 \times (0{\cdot}28)^2} = 0{\cdot}52.$$

Example.—It is found by subsequent experiment that owing to an error in the estimation of the jump the figures, in the last example, should have been $\phi = 35'$ for 1,000 yards.

What difference will this make in the calculated value of C?

Here $$\frac{\sin 2\phi}{R} = 0{\cdot}0^4204$$

While for $$\frac{R}{C} = 2{,}100$$

$$a = 0{\cdot}04287$$

$$a \Big/ \frac{R}{C} = 0{\cdot}0^4204$$

$$\therefore C = \frac{1{,}000}{2{,}100} = 0{\cdot}476.$$

Problem 8.—Knowing the ballistic coefficient (C), the muzzle velocity (V), the angle of projection (ϕ), and the range (R) to find the angle of descent (β).

In the equation

$$\frac{\tan\phi - \tan\theta}{C} = I_V - I_v$$

at the end of a range, R yards or X feet, where the remaining velocity is v f/s,

$$\tan\theta = -\tan\beta,$$

so that

$$\tan\beta = C\,(I_V - I_v) - \tan\phi,$$

and v can be found from

$$S_v = S_V - \frac{X}{C}.$$

Example.—Find the angle of descent at 1,000 yards of the bullets in the Example in Problem 4, page 228.

	D/05.	S/05.
V	2,380	2,820
C	0·521	0·384
R	1,000	1,000
ϕ	51′·5	44·5′
S_V	42,825·2	44,296·7
$\frac{X}{C}$	5,758·2	7,812·6
S_v	37,067·0	36,484·1
v	1,141 f/s	1,086
I_V	0·98447	0·99155
I_v	0·90873	0·89345
$I_V - I_v$	0·07574	0·09810
$C\,(I_V - I_v)$	0·03948	0·03765
Tan ϕ	0·01512	0·01279
Tan β	0·02436	0·02486
β	1° 24′	1° 26′

Calculation of the Angle of Descent from a Table of Elevations and Ranges.

In Fig. 12 a rifle at G is fired with elevation ϕ so as to describe a trajectory, represented by the curved line, and hit a target T at a range of R yards.

Suppose the elevation decreased by a small angle $\Delta\phi$, and draw GT^1 intersecting the trajectory in T^1, and so that the angle $TGT^1 = \Delta\phi$.

Then, assuming the principle of the rigidity of the trajectory, if T^1M be drawn perpendicular to GT, TM will represent the decrease in range, ΔR yards, due to a decrease of elevation, $\Delta\phi$.

And taking TT^1 as a straight line

$$\tan\beta = \frac{T^1M}{TM} = \frac{(R - \Delta R)\ \tan\Delta\phi)}{\Delta R}.$$

Now, as $\Delta\phi$ is a small decrease in elevation, $R - \Delta R$ will not differ seriously from R except at very short ranges. Also if the angles are small we may write β and $\Delta\phi$ for tan β, tan $\Delta\phi$.

And, finally, taking ΔR as the alteration in range, due to 1 minute elevation, we have as a formula for the angle of descent in minutes

$$\beta = \frac{R}{\Delta R} \quad \text{..............................(7),}$$

FIG. 12.

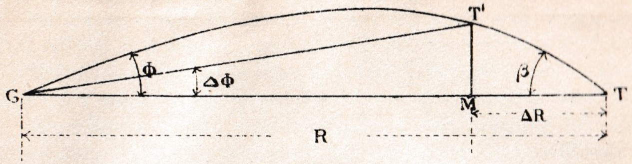


FIG. 13.

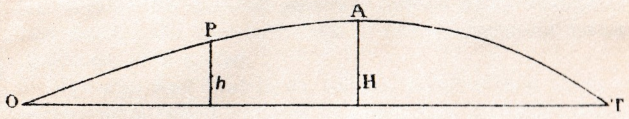


FIG. 14.

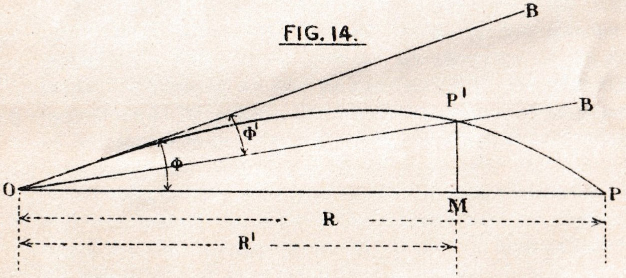
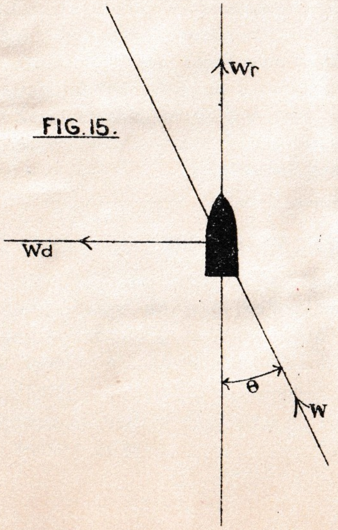


FIG. 15.



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At this stage it may be well to interpolate that the following signs used herein have the following meanings: ϕ, the angle of projection; "V," muzzle velocity; "v," remaining velocity; "C" the ballistic coefficient.

The whole object of the shooting being to get ϕ absolutely correctly for the distance, and as at 1000 yards one minute of angle equals only about ten inches on the target, the necessity of favorable weather, an accurate rifle, and careful shooting will be appreciated, moreover the hits must be upon the point aimed at, and not necessarily in the center of the bull's-eye unless that happens to be the point of aim.

Having shot and ascertained the angle of elevation at which hits were made upon the point of aim, it will be desirable to again test the zero of the rifle, and repeat the shooting if any alteration is found.

Account must be taken of head or rear winds. It is of course best to shoot on a calm day, but if this cannot be, allowance must be made by regarding the range shot at as increased or diminished by half the travel of the wind in the time of flight of the bullet, which involves a knowledge of the speed of the wind, and the use of a table which also requires a knowledge of "C."

A very easy way to compute the time of flight when the angle of elevation is known is to convert this angle into drop then the time of flight is the square root of the drop divided by 16.1, this, of course, dispenses with the use of any table.

Table M is the table employed for the problem in hand. This table gives the sine of twice the angle of projection for the standard projectile, and to use it for our purposes therefore a mathematical adjustment for the difference in the size and weight of the bullet is necessary.

The following is an application of Table M to our problem:

Knowing "ϕ" and "V" for the range "R," to compute "C." Let "ϕ" be 33′, "V" 2900 f/s, and "R" 1000 yards.

Then $\sin 2\phi/R = Ca/R = a\ R/C$, "a" being the figures under R/C and opposite velocity in the table, and $a\ R/C = \sin 2\phi/R$. This is the correct value of R/C and C is found from $C = R\ R/C$. In our example $\sin 2\phi/R = \sin 1° \ 6'/1000 = 0.0000192$. Turning to table M we find opposite "V" 2900 f/s, and under R/C 1900, 0.03633 which, divided by R $1900 = 0.0000191$, and is a little less than the figure we require. Again under R/C 2000 we find 0.03950 which, also divided by R 2000 gives 0.0000197, which is a little more than the required figure. But by interpellation we shall find that the correct figure would lie under 1916, therefore "C" $= 1000/1916 = 0.523$, and our problem is solved just as correctly as we have exactly ascertained the necessary data "V" and "ϕ." With "C" once correctly ascertained the ballistic tables may be employed and will correctly solve every ballistic problem we are likely to encounter.

My acknowledgments are due to Capt. J. H. Hardcastle to whom I am indebted for such knowledge of the application of the ballistic tables as I possess, and as I know many of your readers are in possession of these tables, doubtless some will be interested in learning this method of obtaining the fundamental factor for using them.

This formula will be found sufficiently accurate for rifle fire at all ordinary ranges, and gives us a quick method of estimating the angle of descent once the elevations are known for a number of ranges.

Height of Trajectory.

The assumption made on p. 227, that the vertex of a trajectory is reached at the point of half-time will further enable us to deduce an expression for the height of the trajectory at any point.

Let A, Fig. 13, be the vertex of a trajectory OAT, OT being the horizontal range, and let the whole time of flight be T seconds from O to T.

Then the time from O to A is $\frac{T}{2}$ seconds, and at A, as the bullet is moving horizontally, its vertical velocity must be zero.

Hence the vertical velocity at O must have been $\frac{T}{2} g$ f/s.

Now consider any point P in the trajectory and let the time of flight from O to P be t seconds.

Then if gravity did not act the bullet would, after t seconds, be at a height $\left(\frac{T}{2}g\right) t$ feet above O.

But gravity acting for t seconds will reduce this height by

$$\frac{1}{2} gt^2.$$

Hence the height h feet of P above O will be given by

$$h = \frac{T}{2} gt - \frac{1}{2} gt^2,$$

$$= \frac{1}{2} gt (T - t) \text{ feet} \ldots\ldots\ldots\ldots\ldots\ldots (8).$$

This is known as Sladen's formula.

At the vertex

$$t = \frac{T}{2},$$

and we have for the maximum height H in feet.

$$H = \frac{1}{8} gT^2,$$

or taking $g = 32$,

$$H = 4T^2 = (2T)^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9),$$

in words—the square of double the time of flight in seconds is the height of the vertex in feet.

Plotting Trajectories.

Sladen's formula furnishes us with a convenient method of plotting the trajectory for any range. A suitable number of intermediate ranges are chosen, and the time of flight and thence the height of the trajectory calculated for each of these points.

Setting off the ranges as abscissæ and the height as ordinates, a curve representing the trajectory can be drawn.

In the case of a rifle trajectory owing to the flatness it will generally be found necessary to exaggerate the vertical scale ($h : X = 10 : 1$ say).

If a table of ranges and elevations for a rifle is available the trajectory may be plotted by another method which is approximately correct for flat trajectories.

Let OP (fig. 14) represent the horizontal range R on a suitable scale, and draw OB so that the angle $POB = \phi$, the elevation for the range R.

Let ϕ' be the elevation for some shorter range R′.

Draw OB′ below OB so that angle $BOB' = \phi'$.

Make $OM = R'$, and draw MP perpendicular to OP, cutting OB′ in P.

Then P′ is a point on the trajectory.

Other points P″, P‴...... can be fixed by a similar construction for ranges R″, R‴...... and elevation ϕ'', ϕ'''...... .

This method is, however, somewhat troublesome when the vertical scale has to be exaggerated.

Range Tables.

We are now in a position to calculate a range table for any rifle bullet, given its muzzle velocity and ballistic coefficient.

For any range we can calculate the angle of projection as in Problem 4, page 228, the angle of descent as in Problem 8, page 231, the remaining velocity and time of flight as in Problem 1, page 224.

Where an extensive range table is wanted with values for every hundred yards range, the most convenient plan is to calculate ϕ, β, v, t for say six ranges, and then plot the points so obtained on a large scale on squared paper.

A curve can then be drawn through these points by means of a flexible ruler or "spline," and the hundred yards values read off and tabulated from this curve.

A range table calculated for the ·303 short rifle, with Mark VI ammunition, is shown below, also abridged tables for some other bullets.

RANGE TABLE.

Rifle, Short, M.L.E., ·303, Mark VI cartridge.

C = 0·421.

Range.	Angle of Projection. ϕ.		1′ Elevation alters Range.	Angle of Descent. β.		Remaining Velocity. v.	Time of Flight. t.	Greatest Height. H.
yards.	°	′	yards.	°	′	f/s.	seconds.	feet.
0	0	0	—	0	0	2,060	0·00	0·0
100		4	23·0		4	1,876	0·16	0·1
200		9	20·0		10	1,706	0·32	0·4
300		15	17·6		17	1,548	0·51	1·0
400		21	15·4		26	1,403	0·71	2·0
500		28	13·3		38	1,281	0·93	3·5
600		36	11·6		52	1,178	1·18	5·6
700		45	10·3	1	8	1,103	1·44	8·3
800		55	9·2		27	1,048	1·71	11·7
900	1	7	8·4		47	1,003	2·01	16·1
1,000		19	7·7	2	9	961	2·32	21·6
1,100		32	7·1		34	923	2·64	28·0
1,200		46	6·6	3	0	888	2·97	35·3
1,300	2	2	6·2		28	856	3·31	43·8
1,400		19	5·8		57	826	3·67	53·9
1,500		36	5·5	4	30	796	4·04	65·3
1,600		55	5·2	5	6	767	4·42	78·3
1,700	3	15	4·9		45	739	4·82	92·9
1,800		36	4·6	6	27	711	5·24	109·8
1,900		58	4·3	7	12	684	5·67	128·6
2,000	4	22	4·1	8	0	658	6·11	149·5

The jump with this cartridge is + 4′.

French D/05.

C = 0·521.

R.	ϕ.		β.		v.	t.	H.
yards.	°		°	′	f/s.	seconds.	feet.
0	0	0	0	0	2,380	0·00	0·0
500	0	19	0	25	1,639	0·76	2·3
1,000		52	1	24	1,141	1·87	14·0
1,500	1	44	3	10	942	3·33	44·4
2,000	2	58	5	33	810	5·05	102·2

German S/05.

$C = 0{\cdot}384$.

R.	ϕ.	β.	v.	t.	H.
yards.	° ′	° ′	f/s.	seconds.	feet.
0	0 0	0 0	2,820	0·00	0·0
500	0 14	0 20	1,741	0·68	1·8
1,000	0 44	1 26	1,086	1·80	13·0
1,500	1 41	3 29	864	3·36	45·2
2,000	3 5	6 36	705	5·28	111·7

Ross-Eley ·28.

$C = 0{\cdot}535$.

0	0 0	0 0	2,900	0·00	0·0
500	0 12	0 16	2,082	0·61	1·5
1,000	0 33	0 52	1,428	1·48	8·8
1,500	1 7	2 13	1,060	2·73	29·7
2,000	2 1	4 15	899	4·27	73·0

The range at which the height of the vertex of the trajectory is the same as the height of the target fired at is sometimes referred to as the "*fixed sight range*" for that target; the meaning being that if the rifle is sighted for this range the target will be struck at any shorter range.

The term "danger range" is also applied to the same distance. Taking the average height of an infantry soldier as 5·5 feet the "fixed sight range" or "danger range" against infantry for any particular rifle will be the range at which

$$H = 5{\cdot}5 \text{ feet.}$$

"*Danger space*" has already been defined on p. 195. We may describe it in other words as the horizontal distance over which a target of given height would be struck by a bullet describing a certain trajectory, the descending branch only being considered, as a rule.

The flatter the trajectory the longer will be the "fixed sight range" and the greater the "danger space." Hence the endeavour to make the trajectory of the modern military rifle as flat as possible.

The following examples illustrate the application of the formulæ to some questions of this nature:—

Example (*a*).—Calculate the "fixed sight range" against infantry with the D/05 bullet.

We have to find the range at which

$$H = 5{\cdot}5 \text{ feet,}$$

or as

$$H = 4T^2,$$

the range for a time of flight of $\sqrt{\dfrac{H}{4}}$ seconds.

The work may be arranged as follows :—

$$V = 2{,}380. \qquad C = 0{\cdot}521.$$

$$\begin{aligned}
\text{Log } H &= 0{\cdot}7404 \\
\text{Log } 4 &= 0{\cdot}6021 \\
& \quad\ 0{\cdot}1383 \\
\text{Log } T &= 0{\cdot}0691 \\
\text{Log } C &= \bar{1}{\cdot}7168 \\
\text{Log } \frac{T}{C} &= 0{\cdot}3523 \\
\frac{T}{C} &= 2{\cdot}251 \\
T_V &= 110{\cdot}909 \\
T_v &= 108{\cdot}658 \\
v &= 1{,}392 \text{ f/s} \\
S_V &= 42{,}825{\cdot}2 \\
S_v &= 38{,}753{\cdot}0 \\
\frac{X}{C} &= 4{,}072{\cdot}0 \\
\text{Log } \frac{X}{C} &= 3{\cdot}6098 \\
\text{Log } X &= 3{\cdot}3266 \\
X &= 2{,}121 \text{ feet} \\
R &= 707 \text{ yards}
\end{aligned}$$

the fixed sight range.

Example (*b*).—Find the "danger space" against infantry at 1,000 yards range on level ground with the S/05 bullet, supposing the muzzle of the rifle to be at the level of the ground and aim to be taken at the ground line of the target.

Here we have to find the distance from the target at which the height of the trajectory is 5·5 feet. By Sladen's formula

$$h = 5{\cdot}5 = \frac{1}{2} gt\,(T - t),$$

and from the range table, p. 236,

$$T = 1{\cdot}8 \text{ seconds},$$

$$\therefore\ t^2 - 1{\cdot}8t + 0{\cdot}344 = 0.$$

Solving this quadratic for t we get

$$t = 1{\cdot}58 \text{ or } 0{\cdot}21 \text{ second},$$

the smaller value referring to the "ascending branch" of the trajectory, the larger one to the "descending branch," which is what we are dealing with.

We now have as data,

$$V = 2{,}820 \text{ f/s.} \qquad C = 0{\cdot}384. \qquad t = 1{\cdot}58 \text{ seconds.}$$

$$T_V = 111{\cdot}477$$

$$\frac{t}{C} = 4{\cdot}11$$

$$T_v = 107{\cdot}37$$

$$v = 1{,}148 \text{ f/s}$$

$$S_V = 44{,}296{\cdot}7$$

$$S_v = 37{,}131{\cdot}7$$

$$\frac{s}{C} = 7{,}165{\cdot}0$$

$$s = 2{,}750 \text{ feet.}$$

The danger space is therefore

$$3{,}000 - 2{,}750 = 250 \text{ feet} = 83 \text{ yards.}$$

At long ranges and considerable angles of descent the danger space is approximately given by

$$\frac{h}{3} \cot \omega \text{ yards.}$$

h being the height of the target in feet, ω the angle of arrival. But with the flat trajectory of a rifle at the ranges generally dealt with this is not sufficiently accurate.

Thus calculating the danger space in the last example by this method we would have

$$\frac{5{\cdot}5}{3} \cot 1^\circ\, 26'$$

$$= 73 \text{ yards instead of } 83 \text{ yards.}$$

Example (*c*).—The maximum height of the trajectory of the service ·303 bullet is 21·6 feet at 1,000 yards. What increase of muzzle velocity would be necessary to reduce this height to 16 feet?

Here

$$C = 0{\cdot}421,$$

$$X = 3{,}000 \text{ feet,}$$

$$H = 16 \text{ feet,}$$

$$\therefore T = \sqrt{\frac{H}{t}} = 2 \text{ seconds.}$$

$$\frac{X}{C} = \frac{3{,}000}{0{\cdot}421} = 7{,}125 = S_V - S_v \text{ ....(i),}$$

$$\frac{T}{C} = \frac{2}{0{\cdot}421} = 4{\cdot}75 = T_V - T_v \text{..............(ii).}$$

We must proceed to find by trial and error what value of V in (i) will satisfy (ii).

Try V = ...	2,600	2,400	2,450
S_V	43,579·1	42,895·1	43,068·7
$\frac{X}{C}$	7,125	7,125	7,125
S_v	36,454	35,770	35,944
v	1,084	1,035	1,046
T_V	111·212	110·938	110·010
T_v	106·762	106·115	106·277
$\frac{T}{C}$	4·450	4·823	4·733
	too small.	too large.	nearly correct.

The muzzle velocity would therefore have to be increased to about 2,450 f/s.

Example (*d.*)—A rifle is sighted through the axis of the barrel at a target distant 100 feet. A number of rounds are fired, and the mean point of impact is found to be 1·115 inches above the point aimed at. The mean muzzle velocity is known to be about 2,050 f/s.

What is the jump of the rifle?

In travelling 100 feet the vertical drop of the bullet (h feet) will be given by

$$h = \frac{1}{2} g t^2,$$

where t is the time of flight in seconds.

Considering the short distance of the target from the muzzle we may take with inappreciable error the average velocity over the 100 feet as 2,050 f/s.

Then

$$t = \frac{100}{2{,}050} = 0{\cdot}0487 \text{ seconds},$$

and

$$h = 0{\cdot}038 \text{ feet},$$
$$= 0{\cdot}456 \text{ inches},$$

the drop of the bullet due to gravity in the time t.

If there were no jump the bullet would be 0·456 inches below the point aimed at.

But as it strikes on an average 1·15 inches above the point aimed at there must be a positive jump of

$$\tan^{-1} \frac{1{\cdot}15 + 0{\cdot}456}{1{,}200}$$
$$= 4\tfrac{1}{2} \text{ minutes nearly.}$$

Drift.

Drift.

It is found that the bullet fired from a rifle always deviates to a certain extent from the vertical plane through the axis of the rifle.

This deviation is known as the drift. With bullets having rounded or pointed heads of the usual type the drift is to the right with right-handed rotation and to the left with left-handed rotation. The amount increases with the range and elevation; also, other things being equal, the sharper the twist of the rifling the greater will be the drift.

With regard to the theory of drift, Sir George Greenhill remarks (*The Engineer*, 6th December, 1907): "The baffling problem of drift is a gyroscopic effect, which causes the mean plane of the trajectory to be inclined from the vertical at a small angle of 2 to 3 degrees; but as drift is a side issue of curvature by gravity of the mean track, and no formula has been devised yet to suit the facts, devised on theoretical principles from the physical data, we leave the subject here a challenge to the ingenuity of the scientific artillerist."

This being the state of affairs no discussion of the various theories will be attempted here.

For practical purposes it is sufficient to determine the actual amount of the drift experimentally at different ranges.

With the Lee-Enfield rifle the drift is to the left on account of the left-handed twist of the rifling. At 600 yards the drift amounts to about $5\frac{1}{2}$ inches, at 1,000 yards to about 20 inches. These results were obtained by firing two rifles from a mechanical rest, one of which had right-handed and the other left-handed rifling. The rifles were accurately layed by means of a telescopic sight; first at 100 feet under cover, when the sights were adjusted to make the rifles shoot true for direction, then at 600 and 1,000 yards on a calm day. At each range, half the average distance apart of the points of mean impact of the two rifles in a series of diagrams was taken as the amount of drift. The ammunition used was Mark II, giving 1,960 f/s.

Wind.

We may consider the effect of wind upon a rifle bullet under two heads—

(*a*) The effect on the range.

(*b*) The effect on the direction.

Supposing a wind of W f/s blowing in a direction making an angle θ with the line of fire (fig. 15). Resolving W into two components W_r and W_d parallel to and at right angles to the line of fire we have

$$W_r = W \cos \theta$$

$$W_d = W \sin \theta$$

W_r will be component, influencing the range of the bullet, and its effect is approximately given by Sir George Greenhill's formula

$$\Delta R = \frac{5W_r}{CV}\left(\frac{R}{100}\right)^2 \text{ yards} \ldots\ldots\ldots\ldots\ldots\ldots (10).$$

Where ΔR is the change of range in yards due to a wind, W_r f/s acting on a bullet whose ballistic coefficient is C and muzzle velocity V f/s, at a range of R yards.

For the effect of W_d on the direction we employ Younghusband's adaption of Didion's solution.

$$S = W_d (T - t) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (11).$$

Where S is the lateral deviation in feet, T is the time of flight, and t is the time of flight over the range R yards if the muzzle velocity V is maintained throughout, as in vacuo, *i.e.*,

$$t = \frac{3R}{V}$$

It is sometimes more convenient to use a formula with the deflection in minutes (δ), and the wind speed in miles per hour (M). The relation is then approximately for rifles.

$$\delta = \frac{M \times R}{C \times 150} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (12).$$

As an example we may calculate the alteration in range and deflection necessary for a ·303 bullet at ranges of 1,000 yards if a rear wind of 50 f/s be blowing at 20° to the line of fire.

We have

$$W = 20 \text{ f/s.} \qquad V = 2{,}060 \text{ f/s.} \qquad C = 0{\cdot}421.$$

$$W_r = 20 \cos 20^\circ = 18{\cdot}8 \text{ f/s}$$

$$W_d = 20 \sin 20^\circ = 6{\cdot}8 \text{ f/s.}$$

For range

$$\begin{aligned} \Delta R &= \frac{5W_r}{CV}\left(\frac{R}{100}\right) \\ &= \frac{5 \times 18{\cdot}8}{0{\cdot}421 \times 2{,}060} \times 100 \\ &= 10{\cdot}8 \text{ yards.} \end{aligned}$$

For deflection

$$\begin{aligned} &= W_d\left(T - \frac{3R}{V}\right) \text{ feet} \\ &= 6{\cdot}8\left(2{\cdot}32 - \frac{3{,}000}{2{,}060}\right) \\ &= 5{\cdot}9 \text{ feet,} \end{aligned}$$

equivalent to about 7 minutes at 1,000 yards.

Or using formula (12)

$$\begin{aligned} \delta &= \frac{M \times R}{C \times 150} \\ &= \frac{4{\cdot}65 \times 1{,}000}{0{\cdot}421 \times 150} \\ &= 7{\cdot}3 \text{ minutes.} \end{aligned}$$

Summary of Notation.

Formulæ.

$$C = \frac{w}{nd^2} = \text{the ballistic coefficient.}$$

Where

w = weight of projectile in lbs.,
d = effective diameter of projectile in inches,
n = coefficient of reduction = $\kappa\sigma\tau$,

and

κ = coefficient of shape of head,
σ = coefficient of steadiness of flight,
τ = coefficient of tenuity.
V = muzzle velocity in f/s,
v = remaining velocity in f/s,
R = range in yards,
X = range in feet.

$$\frac{t}{C} = T_V - T_v \text{.....................Table H.}$$

Where t is the time in seconds it would take for the velocity of a projectile with ballistic coefficient C to fall from V to v f/s.

$$\frac{s}{C} = S_V - S_v \text{.....................Table K.}$$

Where s is the space in feet traversed by a projectile of ballistic coefficient C while its velocity falls from V to v f/s.

$$\frac{\tan\phi - \tan\theta}{C} = I_V - I_v \text{ ....Table L.}$$

Where ϕ denotes the angle with the horizontal made by a tangent to the trajectory of a projectile of ballistic coefficient C, at the point where its velocity is V, and θ denotes the angle when the velocity is v.

ϕ = angle of projection,
β = angle of descent,
$\sin 2\phi = Ca$ ....Table M.

Where a is given in Table for reduced range $\frac{R}{C}$ and muzzle velocity V.

$$\beta = \frac{R}{\Delta R}.$$

When β = angle of descent in minutes at range R yards, and ΔR is difference in range due to 1 minute elevation at the range R.

$$h = \frac{1}{2} gt\,(T - t).$$

$$H = 4(T)^2.$$

Where h = height in feet after time t seconds, when whole time of flight is T seconds.

H = greatest height of trajectory in feet.

APPENDICES.

APPEN

TABL

BREECH-LOADING RIFLES OF

Country	Prussia.	France.	Austria.	Belgium.	Denmark, Norway and Sweden, Spain.	England.	
Pattern of the Year ...	1841	1866	1868–73	1867	1867 1867 1871	1853–66	1871
Designation	Needle Gun (Dreyse).	Chassepôt.	Werndl.	Albini-Bräendlin.	Remington.	Snider.	Martini-Henry.
Breech Mechanism ...	Bolt.	Bolt.	Block.	Block.	Block.	Block.	Block.
Weight— Without bayonet ... With „ ...	 10 lb. 4 oz. 11 lb. 0 oz.	 9 lb. 5½ oz. 10 lb. 12½ oz.	 9 lb. 13½ oz. 11 lb. 7 oz.	 9 lb. 14 oz. 10 lb. 10¼ oz.	 9 lb. 5½ oz. 10 lb. 13½ oz.	 9 lb. 1 oz. 10 lb. 0 oz.	 9 lb. 0 oz. 9 lb. 12 oz.
Length— Without bayonet ... With „ ...	 4 ft. 5½ ins. 6 ft. 1½ ins.	 4 ft. 3½ ins. 6 ft. 2 ins.	 4 ft. 2 ins. 6 ft. 0 ins.	 4 ft. 5½ ins. 6 ft. 0 ins.	 4 ft. 2¼ ins. 6 ft. 1 in.	 4 ft. 7 ins. 6 ft. 0½ in.	 4 ft. 1½ ins. 5 ft. 11½ ins.
Barrel— Length ... ... ins. Calibre ... { mm. Calibre ... { ins. Number of grooves ... Depth „ ins.	 35·43 15·43 ·607 4 ·0307	 32·28 11 ·433 4 ·0118	 33·2 11 ·433 6 ·0072	 38·2 11 ·433 4 ·0118	 35·2 11 ·433 6 ·0079	 39 14·67 ·577 3 ·005–·012	 33·2 11·43 ·45 7 ·007–·00[illegible]
Rifling— Twist, 1 turn in ins. „ „ calibre „ direction ...	 28·82 47·5 To right	 21·2 49 To left	 29·52 68 To right	 21·2 49 To right	 20 46 To right	 78 135 To right	 22 48·8 To right
Sights— Lowest for { metres Lowest for { yards Highest for { metres Highest for { yards	 350 paces 287 800 paces 656	 200 218·7 1200 1312·3	 200 paces 164 2100 paces 1722	 300 328 2100 2296·6	 200 218·7 1000 1093·6	 91·4 100 914·38 1000	 91·4 100 1325 1450
Cartridge— Length ... ... ins. Weight ... ... grs.	 2·36 617·3	 2·68 494	 3·07 656	 2·59 648	 2·98 639	 2·45 715	 3·2 758
Bullet— Material...	 Lead	 Lead	 Lead	 Hard lead	 Hard lead	 Lead	 Hard lead
Length ... ... ins. Diameter ... „ Weight ... ... grs.	1·12 ·5315 478	·98 ·4646 385·8	1·063 ·433 370	1·10 ·433 386	1·10 ·437 387·4	1·042 ·573 480	1·27 ·45 480
Charge— Weight ... ... grs.	 74·15	 86·42	 77·16	 80·25	 77·16	 70	 85
Value of W/d²	·168	·293	·282	·294	·305	·206	·330
Muzzle Velocity ... f.s.	1000	1328	1440	...	1340	1240	1350
Maximum Range...yards	...	...	...	...	3062	...	...

DIX I.

I.

LARGE CALIBRE (SINGLE LOADERS).

France, Greece.	Germany.	Holland.	Italy.	Portugal.	Turkey, Roumania.	Russia, Bulgaria.	Servia.	United States.
1874 1878	1871	1871	1871	1885	1874 1878	1871 1880	1881	1886
Gras.	Mauser.	Beaumont.	Vetterli.	Guedes.	Peabody-Martini.	Berdan II.	Mauser-Milanovic.	Springfield.
Bolt.	Bolt.	Bolt.	Bolt.	Bolt.	Block.	Bolt.	Bolt.	Block.
9 lb. 11 oz. 10 lb. 7⅓ oz.	10 lb. 4 oz. 11 lb. 12 oz.	9 lb. 9½ oz. 10 lb. 6½ oz	9 lb. 9 oz. 10 lb. 8 oz.	9 lb. 0½ oz. 10 lb. 4½ oz.	9 lb. 10 oz. 10 lb. 8½ oz.	9 lb. 12½ oz. 11 lb. 0 oz.	10 lb. 4 oz. 11 lb. 10 oz.	9 lb. 5¼ oz. 10 lb. 1 oz.
4 ft. 3¼ ins. 6 ft. 1 in.	4 ft. 4¾ ins. 6 ft. 0½ in.	4 ft. 4 ins. 6 ft. 0 in.	4 ft. 5½ ins. 6 ft. 2 ins.	3 ft. 11⅔ ins. 5 ft. 6 ins.	4 ft. 1 in. 5 ft. 9 ins.	4 ft. 5 in. 6 ft. 1¼ ins.	4 ft. 2¾ ins. 5 ft. 9½ ins.	4 ft. 3½ ins. 5 ft. 9½ ins.
32·3 11 ·433 4 ·0098	33·46 11 ·433 4 ·0157	32·75 11 ·433 4 ·0118	33·9 10·4 ·4095 4 ·0089	38·3 ·8 ·315 4 ·0079	33·2 11·43 ·45 5 ·007–·009	32·75 10·66 ·42 6 ·0079	31·5 10·15 ·4 4 ·0067	32·5 11·43 ·45 3 ·0059
21·65 50 To right	21·65 50 To right	29·53 68·4 To right	26 63·5 To right	11·4 36 To right	22 48·8 To right	22 52·4 To right	21·6 54 To right	22 48·8 To right
300 328 1800 1968·5	300 328 1600 1750	100 109·3 1800 1968·5	200 218·7 1600 1750	300 328 2000 2187·3	109·3 100 1280 1400	300 paces 287 1400 paces 1148	300 paces 287 2700 paces 2214	... ...
2·99 676	3·07 660·5	2·57 664	2·59 540	3·24 540	3·2 802	2·95 610	3·1 632·7	... 752
Hard lead	Lead	Hard lead	Hard lead	Hard lead with copper envelope, point bare	Hard lead	Hard lead	Hard lead	Hard lead
1·063 ·433 386	1·0827 ·433 386	1·063 ·4567 386	·996 ·4193 313·3	1·29 ·315 247	1·27 ·45 480	1·063 ·4272 370	1·145 ·4016 335·6	1·322 ·4595 500
81·32	77·16	77·16	61·73	71	85	77·16	71	70
·294	·294	·264	·266	·355	·339	·299	·297	·352
1493	1427	1476	1430	...	1380	1444	1580	1300
3171	3281	3281	3007	...	...	...	3554	...

TABLE

BREECH-LOADING RIFLES OF LARGE

Country		Austria.	France. (Marine Infantry.)	Germany.
Pattern of the Year		1886.	1878.	1884.
Designation		Mannlicher.	Kropatschek.	Mauser and Commission.
Magazine System		Fixed vertical box.	Tube in fore-end.	Tube in fore-end.
No. of Cartridges in Magazine ...		5	7	8
Weight—				
Without bayonet...		9 lb. 15½ oz.	10 lb. 4 oz.	10 lb. 2¼ oz.
With „		10 lb. 12½ oz.	11 lb. 7¾ oz.	11 lb. 0½ oz.
Length—				
Without bayonet...		4 ft. 4 ins.	4 ft. 1 in.	4 ft. 3 ins.
With „		5 ft. 1 in.	5 ft. 9¾ ins.	5 ft. 9½ ins.
Barrel—				
Length	ins.	31·7	29·5	31·5
Calibre	mm.	11	11	11
	ins.	·433	·433	·433
Number of grooves		6	4	4
Depth	ins.	·0079	·0087	·0079
Rifling—				
Twist, 1 turn in	ins.	28·4	21·65	21·65
„ „ ...	calibre	65·6	50	50
„ direction		To right	To left	To right
Sights—				
Lowest for... ...	metres	200 paces	300	200
	yards	164	328	218·7
Highest for ...	metres	2300 paces	1800	1600
	yards	1886	1968·5	1750
Cartridges—				
Length	ins.	2·91	2·99	3·07
Weight	grs.	656	676	663
Bullet—				
Material		Hardened lead	Hardened lead	Hardened lead
Length	ins.	1·063	1·063	1·0827
Diameter	ins.	·433	·423	·433
Weight	grs.	370	386	386
Charge—				
Weight	grs.	77·16	81·32	77·16
Value of W/d²		·282	·294	·294
Muzzle Velocity	f.s.	1440	1493	1427
Maximum Range	yards	... ...	3171	3281

II.

CALIBRE (MAGAZINE ARMS).

Holland.	Italy.	Norway.	Switzerland.	Turkey.
1871-88.	1871-87.	1887.	1869-81.	1887.
Beaumont-Vitali.	Vetterli-Vitali.	Jarman.	Vetterli.	Mauser.
Fixed vertical box.	Fixed vertical box.	Tube in fore-end.	Tube in fore-end.	Tube in fore-end.
4	4	8	12	8
9 lb. 15½ oz. 10 lb. 13 oz.	9 lb. 13¾ oz. 11 lb. 2½ oz.	9 lb. 12 oz. 10 lb. 10½ oz.	10 lb. 2¼ oz. 11 lb. 6 oz.	9 lb. 6½ oz. 10 lb. 15½ oz.
4 ft. 4 ins. 6 ft. 0 in.	4 ft. 6 ins. 6 ft. 1 in.	4 ft. 5 ins. 5 ft. 10¾ ins.	4 ft. 4 ins. 5 ft. 10¼ ins.	4 ft. 1½ ins. 5 ft. 8 ins.
32·75 11 ·433 4 ·0118	34 10·4 ·4095 4 ·0089	32·3 10·15 ·4 4 ·0067	33·2 10·4 ·4095 4 ·0089	30·4 9·5 ·374 4 ·0059
29·53 68·4 To right	26 63·5 To right	22·4 56·4 To left	26 63·5 To right	19·7 52·7 To right
100 109·3 1800 1968·5	200 218·7 1600 1750	200 218·7 2400 2625	225 246 1600 1750	200 218·7 1600 1750
2·67 664	2·6 509	3·07 636	2·2 469	2·47 555·5
Hardened lead 1·063 ·4567 386	Hardened lead, copper envelope 1·0118 ·425 313	Hardened lead 1·0866 ·403 383	Hardened lead ·9961 ·419 313	Hardened lead 1·0473 ·382 284
77·16	64	73·3	61·7	69·4
·264	·266	·347	·266	·288
1476	1525	... ...	1338	1758
3281	... ...	... ...	3062	... ...

RIFLES AND CARBINES OF SMALL

Nomenclature.	Arm.							
	Weight.				Length.			
	With.		Without.		With.		Without.	
	Bayonet or sword-bayonet.							
	lb.	oz.	lb.	oz.	ft.	in.	ft.	in.
MARTINI-METFORD.								
Carbine, Artillery, Mark I, converted from M.-H. Art., I ...	8	$11\frac{3}{4}$	7	$12\frac{1}{4}$	4	$11\frac{13}{16}$	3	$1\frac{5}{8}$
,, ,, ,, II ,, ,, ,, Rifle, II...	8	$0\frac{1}{2}$	7	1	4	$1\frac{5}{16}$	3	$1\frac{5}{16}$
,, ,, ,, III ,, ,, ,, ,, III	8	$2\frac{1}{2}$	7	3	4	$1\frac{5}{16}$	3	$1\frac{5}{16}$
,, Cavalry, ,, I* ,, ,, ,, Cav., I ...	...		8	$1\frac{1}{2}$	...		3	$1\frac{5}{8}$
,, ,, ,, II* ,, ,, ,, Art., I ...	...		8	4	...		3	$1\frac{5}{8}$
,, ,, ,, III ,, ,, ,, Rifle, II...	...		6	11	...		3	$1\frac{5}{16}$
MARTINI-ENFIELD.								
Carbine, Art., Mark I, converted from M.-H. Rifle, III ...	8	4	7	$4\frac{1}{2}$	4	$1\frac{5}{16}$	3	$1\frac{5}{16}$
,, ,, ,, I* ,, ,, ,, ,, III ...	8	4	7	$4\frac{1}{2}$	4	$1\frac{5}{16}$	3	$1\frac{5}{16}$
,, ,, ,, II ,, ,, ,, Art., I & III...	8	4	7	$4\frac{1}{2}$	4	$1\frac{5}{16}$	3	$1\frac{5}{16}$
,, ,, ,, II* ,, ,, ,, I & III..	8	4	7	$4\frac{1}{2}$	4	$1\frac{5}{16}$	3	$1\frac{5}{16}$
,, ,, ,, III ,, ,, ,, Rifle, II ...	8	4	7	$4\frac{1}{2}$	4	$1\frac{5}{16}$	3	$1\frac{5}{16}$
,, Cav., ,, I ,, ,, ,, ,, II ...	...		6	11	...		3	$1\frac{5}{16}$
,, ,, ,, I* ,, ,, ,, ,, II ...	...		6	11	...		3	$1\frac{5}{16}$
Rifle, Mark I, converted from M.-H. Rifle, III	9	6	8	5	5	$8\frac{9}{16}$	3	$10\frac{1}{2}$
,, ,, II ,, ,, ,, ,, II	9	6	8	5	5	$8\frac{9}{16}$	3	$10\frac{1}{2}$
LEE-METFORD.								
Carbine, magazine, Mark I	...		7	7	...		3	$3\frac{5}{16}$
Rifle, ,, ,, I*	10	$7\frac{1}{2}$	9	8	5	$1\frac{1}{2}$	4	$1\frac{1}{2}$
,, ,, ,, II	10	$7\frac{1}{2}$	9	8	5	$1\frac{1}{2}$	4	$1\frac{1}{2}$
,, ,, ,, II*	10	$3\frac{1}{2}$	9	4	5	$1\frac{1}{2}$	4	$1\frac{1}{2}$
LEE-ENFIELD.								
Carbine, magazine, Mark I	...		7	7	...		3	$3\frac{5}{16}$
,, ,, ,, I*	...		7	7	...		3	$3\frac{5}{16}$
Rifle, ,, ,, I and I*	10	$3\frac{1}{2}$	9	4	5	$1\frac{1}{2}$	4	$1\frac{1}{2}$
,, ,, C.L., Mark I*	10	$4\frac{1}{2}$	9	5	5	$1\frac{1}{2}$	4	$1\frac{1}{2}$
Short rifle, ,, Mark I	9	3	8	$2\frac{1}{2}$	5	$1\frac{11}{16}$	3	$8\frac{9}{16}$
,, ,, ,, ,, I*	9	$7\frac{1}{2}$	8	7	5	$1\frac{11}{16}$	3	$8\frac{9}{16}$
,, ,, ,, ,, III	9	11	8	$10\frac{1}{2}$	5	$1\frac{11}{16}$	3	$8\frac{9}{16}$
,, ,, ,, converted, Mark II	9	3	8	$2\frac{1}{2}$	5	$1\frac{11}{16}$	3	$8\frac{9}{16}$
,, ,, ,, ,, ,, II*	9	$7\frac{1}{2}$	8	7	5	$1\frac{11}{16}$	3	$8\frac{9}{16}$
,, ,, ,, ,, ,, IV	9	15	8	$14\frac{1}{2}$	5	$1\frac{11}{16}$	3	$8\frac{9}{16}$

·III.

CALIBRE OF THE BRITISH SERVICE.

Barrel.								
Dimensions.		Rifling.				Arm sighted to.	Initial velocity f.s.	Service.
				Nature.				
Length.	Calibre.	No. of grooves.	Depth of grooves.	Description.	Twist turn.			
ft. in.	in.		in.		in.	yds.		
1 9⅜	·303	7	·0045	Metford	1 in 10, left hand	1400	1940	None made beyond pattern arms.
1 9	·303	7	·0045	Metford	1 in 10, left hand	2000	1940	
1 9	·303	7	·0045	Metford	1 in 10, left hand	2000	1940	
1 9⅜	·303	7	·0045	Metford	1 in 10, left hand	1400	1940	
1 9⅜	·303	7	·0045	Metford	1 in 10, left hand	1400	1940	
1 9	·303	7	·0045	Metford	1 in 10, left hand	2000	1940	
1 9	·303	5	·0065	Enfield	1 in 10, left hand	2000	1940	
1 9	·303	5	·0065	Enfield	1 in 10, left hand	2000	1940	
1 9	·303	5	·0065	Enfield	1 in 10, left hand	2000	1940	
1 9	·303	5	·0065	Enfield	1 in 10, left hand	2000	1940	
1 9	·303	5	·0065	Enfield	1 in 10, left hand	2000	1940	
1 9	·303	5	·0065	Enfield	1 in 10, left hand	2000	1940	
1 9	·303	5	·0065	Enfield	1 in 10, left hand	2000	1940	
2 6$\frac{3}{16}$	·303	5	·0065	Enfield	1 in 10, left hand	1800	2060	
2 6$\frac{3}{16}$	·303	5	·0065	Enfield	1 in 10, left hand	1800	2060	
1 8¾	·303	7	·0045	Metford	1 in 10, left hand	2000	1940	
2 6$\frac{3}{16}$	·303	7	·0045	Metford	1 in 10, left hand	2900	2060	
2 6$\frac{3}{16}$	·303	7	·0045	Metford	1 in 10, left hand	2800	2060	
2 6$\frac{3}{16}$	·303	7	·0045	Metford	1 in 10, left hand	2800	2060	
1 8¾	·303	5	·0065	Enfield	1 in 10, left hand	2000	1940	
1 8¾	·303	5	·0065	Enfield	1 in 10, left hand	2000	1940	
2 6$\frac{3}{16}$	·303	5	·0065	Enfield	1 in 10, left hand	2800	2060	
2 6$\frac{3}{16}$	·303	5	·0065	Enfield	1 in 10, left hand	2800	2060	
2 1$\frac{3}{16}$	·303	5	·0058	Enfield	1 in 10, left hand	2800	2060	Length of short rifles is shown with pattern 1907 sword-bayonet.
2 1$\frac{3}{16}$	·303	5	·0058	Enfield	1 in 10, left hand	2800	2060	
2 1$\frac{3}{16}$	·303	5	·0058	Enfield	1 in 10, left hand	2800	2060	
2 1$\frac{3}{16}$	·303	5	·0058	Enfield	1 in 10, left hand	2800	2060	
2 1$\frac{3}{16}$	·303	5	·0058	Enfield	1 in 10, left hand	2800	2060	
2 1$\frac{3}{16}$	·303	5	·0058	Enfield	1 in 10, left hand	2800	2060	

Table V.

List of Components of Rifle, Short, Magazine, Lee-Enfield (Mark III), showing which are special to this rifle, and which are common to other "marks" of short rifles :—

Component.	Special or Common.
Bands—	Common to—
Inner	Marks III and converted IV.
Outer	All marks.
Blades, foresight	Marks III and converted IV.
Barrel	
Bead, pointer, dial sight	All marks.
Bed, backsight	Marks III and converted IV.
Block, band, foresight	All marks.
Body	Special to Mark III.
Bolts—	Common to—
Breech	All marks.
Locking	Marks III and converted IV.
Stock	Marks I, 1*, converted II, and III.
Bracket, swivel, butt..	Marks I*, converted II*, III, and converted IV.
Caps—	
Handguard, front	All marks.
Nose	Marks III and converted IV, but may be used to replace rose-caps fitted to other marks.
Case, magazine	All marks.
Catches—	
Magazine	
Safety, bolt, locking	
Slide, backsight	Marks III and converted IV.
Clip, stop, magazine..	All marks.
Cocking-piece..	
Collar, screw, front, trigger-guard..	
Cut-off	
Disc, marking, butt	Marks I, I*, converted II, and III.
Extractor	All marks.
Guards—	
Hand—	
Front	Marks III and converted IV.
Rear	
Trigger	All marks.
Heads—	
Breech bolt	Marks III and converted IV.
Screw, windgauge..	
Key, block, band, foresight.. ..	All marks.
Leaf, backsight	Marks III and converted IV.
Nut screw—	
Protector, backsight	
Back, nose-cap	All marks.

TABLE V—*continued.*

Component.	Special or Common.
Pins—	
Axis—	Common to—
Backsight	Marks III and converted IV.
Trap, butt plate	Marks I, I*, and converted II, fitted with No. 2 butt plate, and III.
Worm, fine-adjustment, catch, slide, backsight	Marks III and converted IV.
Catch, magazine	All marks.
Fixing—	
Bed, backsight	Marks III and converted IV.
Block, band, foresight	All marks.
Head, screw, windgauge	Marks III and converted IV.
Washer, pin, axis, backsight	All marks.
Joint, band, outer	
Screwed, fore-end	Marks I, I*, and III.
Stop—	
Band, outer	All marks. Same as "Pin, stop, band, lower M.L.M. rifle."
Bolt, locking	Marks III and converted IV.
Trigger	All marks.
Plates—	
Butt	Marks I* and III, and also to I and converted II when fitted with No. 2 brass butt plates.
Keeper, stock bolt	All marks.
Sight, dial	Marks III and converted IV.
Platform, magazine	All marks.
Pointer, sight, dial	
Protector, sight, back	Marks III and converted IV.
Rivets, string, handguard	
Screws—	
Band, inner	All marks.
Cap, nose—	
Back	
Front	
Catch, slide, backsight	Marks III and converted IV.
Cut-off	All marks.
Disc, marking, butt	Marks I, I*, converted II and III.
Ejector	All marks.
Extractor	
Guard, trigger—	
Back	Marks I, I*, and III.
Front	All marks.
Handguard cap	All marks. Same as "Screw, keeper, fine adjustment, and handguard cap, &c."
Keeper, striker	All marks.
Plate, butt	
Protector, backsight	Marks III and converted IV.
Sear	All marks.

TABLE V—*continued.*

Component.	Special or Common.
Screws—	
Sight, dial—	Common to—
Fixing	All marks.
Pivoting	All marks.
Spring—	
Sight, aperture	Marks I, I*, and III.
Trap, butt plate	Marks I* and III, and I and converted II when fitted with brass butt plates.
Sight, back	Marks III and converted IV.
Bracket, swivel butt	Marks I*, converted II*, III, and converted IV. Same as "Screw, strap, butt plate, iron."
Swivel	All marks.
Windgauge, backsight	Marks III and converted IV.
Sear	All marks.
Sight, aperture	All marks.
Slide, backsight	Marks III and converted IV.
Springs—	
Auxiliary, platform, magazine ..	All marks fitted with the No. 2 magazine.
Catch, slide, sight, back	Marks III and converted IV.
Extractor	All marks.
Guard, hand, rear, double ..	All marks.
Main	All marks.
Platform, magazine	All marks.
Retaining breech-bolt	All marks.
Screw—	
Band, inner	All marks.
Windgauge, backsight	Marks III and converted IV.
Sear..	All marks.
Sight—	
Aperture..	Special to Mark III, but may be used to replace similar spring in Marks I and I*.
Back	Common to— Marks III and converted IV, but may be used to replace similar spring in all other marks.
Dial	All marks.
Trap, butt plate	Marks I* and III, and I and converted II, when fitted with brass butt plates.
Stud, fore-end	All marks.
Windgauge, backsight	Marks III and converted IV.
Stocks—	
Butt (long, normal, or short) ..	Marks I* and III.
Fore-end	Special to Mark III; may be used for converted Mark IV, if required.
Striker	Common to— All marks.

TABLE V—*continued.*

Component.	Special or Common.
Studs—	Common to—
Clip, stop, magazine	All marks.
Fore-end	All marks fitted with stud and spring.
Swivels—	
Band, &c.	All marks.
Piling	All marks.
Trap, butt plate	Marks I, I*, and converted II, fitted with a No. 2 butt plate, and III.
Trigger	All marks.
Wad, bolt, stock	Marks I*, and converted II*, III and converted IV. Also Marks I and II when fitted with brass butt plate.
Washers—	
Bolt, stock	All marks.
Guard, hand	All marks.
Pin, axis, backsight	All marks.
Screw, fixing, dial sight (and nut, screw, protector, backsight) ..	All marks, but in Marks III and converted IV one additional for "Washer, nut, screw, protector, backsight."
Spring, band, inner	All marks.
Windgauge, backsight	Marks III and converted IV.
Worm, fine—adjustment, backsight	Marks III and converted IV.

TABLE VI.

List of Components of Rifle, Short, Magazine, Lee-Enfield, converted (Mark IV), which differ from those of Mark III.

This Rifle is converted from Rifle, M.L.E., Marks I and I*; and M.L.M., Marks II and II*. Its weight is 8 lbs. 14½ ozs., and it is the same as the Mark III arm in all details, the following components excepted :—

Component.	Remarks.
Body	Special to converted Mark IV.
Bolt, stock	Same as M.L.E., No. 2.
Cut-off	Converted, and common to all short rifles.
Disc, marking, butt	Omitted. Marking on strap of butt plate.
Pin, axis, trap, butt plate	Same as M.L.M.
Plate, butt	Same as M.L.M., Mark II.
Rivet, fore-end	Same as M.L.M. Not removed on conversion.

TABLE VI—*continued.*

Component.	Remarks.
Screw—	
Disc, marking, butt	Omitted from converted Mark IV.
Guard, trigger, back	Same as M.L.M.
Spring, trap, butt plate	Same as M.L.M.
Spring, sight, aperture	Same as M.L.M.
Strap, butt plate, iron	Also used for "Bracket, swivel, butt," in short rifles fitted with that component.
Spring—	
Sight, aperture	Same as M.L.M.
Trap, butt plate	Same as M.L.M.
Stock—	
Butt	Same as M.L.E.R.S., converted, Mark II*.
Fore-end	Special to converted Mark IV. Rivet and two washers, instead of screwed pin as in Mark III; interchangeability of fore-ends not affected.
Trap, butt plate	Same as M.L.M.R., Mark II.
Washer, rivet, fore-end	Same as M.L.M. Not removed on conversion.

TABLE VII.

List of Components of Rifle, Charger-Loading, Magazine, Lee-Enfield (Mark I*), showing which are special to this Rifle, and which are common to other arms.

This rifle is converted to Charger-Loading from Rifles, Magazine, Lee-Enfield, Marks I and I*; and Lee-Metford, Marks II and II*. Average weight of rifles, 9 lb. 5 oz.

Component.	Special or Common.
Bands, lower, M.L.M.R., II ..	Common.
Barrels—	
M.L.M.C.L.R., II	Special to M.L.E.C.L.R., I*, that have been converted from M.L.M.R., II and II*.
M.L.E.C.L.R. I*	Special to M.L.E.C.L.R., I*, but will be found in M.L.M.C.L.R., II, that are re-barrelled with barrels having "Enfield" rifling.

TABLE VII—*continued.*

Component.	Special or Common.
Beads, pointer, dial sight, M.L.M.R., II	Common.
Beds, backsight, M.L.E.C.L.R., I* ..	Special to M.L.E.C.L.R., I*.
Blades, foresight—	
M.L.M.C.L.R., II	Special to M.L.E.C.L.R., I*, fitted with barrels having "Metford" rifling.
M.L.E.C.L.R., I*	Special to M.L.E.C.L.R., I*.
Bodies, M.L.E.C.L.R., I*	Special to M.L.M.C.L.R., II, and M.L.E.C.L.R., I*.
Bolts—	
Breech—	
M.L.E.C.L.R., I*	Special to M.L.E.C.L.R., I*.
Stock, M.L.E., No. 2	
Caps, nose, M.L.E.R.	
Cases, magazine, M.L.E.R S., I, No. 2	
Catches—	
Magazine, M.L.M.R., II	
Safety, M.L.M.C...	Common.
Clips, stop, magazine, M.L.E.R.S., I.	
Cocking pieces—	
M.L.M.C.	
Collars, screw, guard, trigger, front, M.L.M.	
Cut-offs, M.L.E.R.S., I	Common. (Newly manufactured cut-offs, *i.e.*, not converted, are of M.L.E.R.S., I* or III, pattern.
Extractors, M.L.E.R.S., I	
Guards—	Common.
Hand, M.L.M.R., II	
Trigger, M.L.E.C.L.R., I* ..	
Heads—	
Breech bolt, M.L.E.C.L.R., I* ..	
Screw, windgauge, backsight, M.L.E.C.L.R., I*	Special to M.L.E.C.L.R., I*.
Leaves, backsight, M.L.E.C.L.R., I*	
Nut, clamping, slide, backsight, M.L.E.C.L.R., I*	
Pins—	
Axis—	
Backsight, M.L.M.R.	
Trap, butt plate, M.L.M. ..	
Catch—	Common.
Magazine, M.L.M.	
Safety, M.L.M.C.	
Fixing, head, screw, windgauge, M.L.E.C.L.R., I*	Special to M.L.E.C.L.R., I*.
Stop, band, lower, M.L.M.R. ..	
Trigger, M.L.M.	
Plates—	
Butt, M.L.M.R., II	Common.
Keeper, stockbolt, M.L.E.R.S., I..	
Sight, dial, M.L.M.R., II ..	

TABLE VII—*continued.*

Component.	Special or Common.
Platforms, magazine, M.L.E.R.S., I	Common.
Pointers, sight, dial, M.L.M.R., II..	
Protectors—	
Foresight—	
M.L.M.C.L.R., II	Special to M.L.E.C.L.R., I*, fitted with barrels having "Metford" rifling.
M.L.E.C.L.R., I*	Special to M.L.E.C.L.R., I*, with barrels having "Enfield" rifling.
Rivets—	
Fore-end, M.L.M...	Common.
Spring, handguard, M.L.M. ..	
Screws—	
Band, lower, M.L.M.R., II ..	
Bed, backsight, M.L.M.R. ..	
Cap, nose, M.L.M.R.	
Cut-off, M.L.M.	
Ejector, M.L.M.	
Extractor, M.L.M.	
Guard, trigger—	
M.L.M.—	
Back	
Front	
Keeper, striker—	
M.L.M.C.	
Plate, butt, iron	
Protector, foresight, M.L.E.C.L.R., I*	Special to M.L.E.C.L.R., I*.
Sear, M.L.M.	Common.
Sight—	
Aperture, M.L.M.R.	
Dial, M.L.M., fixing	
" " pivot	
Spring—	
Sight—	
Aperture, M.L.M.	
Back, M.L.M.	
Trap, butt plate, M.L.M. ..	
Stop, slide, backsight, M.L.E.C.L.R., I*	Special to M.L.E.C.L.R., I*.
Strap, butt plate, iron	Common.
Swivel, piling, M.L.M.R., II ..	
Windgauge, M.L.E.C.L.R., I* ..	Special to M.L.E.C.L.R., I*.
Sears, M.L.M.R., II..	Common.
Sights, aperture, M.L.M.R... ..	
Slides, backsight, M.L.E.C.L.R., I*	Special to M.L.E.C.L.R., I*.
Springs—	
Auxiliary, platform, magazine, M.L.E.R.S., I, No. 2	Common.
Extractor, M.L.M.	
Guard, hand, M.L.M.R., II—	
Lower	
Upper	

TABLE VII—*continued.*

Component.	Special or Common.
Springs—	
Main, M.L.M.	Common.
Pin, catch, safety, M.L.M.C. ..	Common.
Platform, magazine, M.L.E.R.S., I	Common.
Retaining, breech bolt, M.L.M ..	Common.
Sear, M.L.M.	Common.
Sight—	
Aperture, M.L.M.	Common.
Back, M.L.M.R.	Common.
Dial, M.L.M.	Common.
Slide, backsight, M.L.E.C.L.R., I*	Special to M.L.E.C.L.R., I*.
Trap, butt plate, M.L.M.. ..	Common.
Windgauge, backsight, M.L.E.C.L.R., I*	Special to M.L.E.C.L.R., I*.
Stocks—	
Butt, M.L.M.R., II, No. 2 (long, normal, or short)	Common.
Fore-end, M.L.E.C.L.R., I* ..	Special to M.L.E.C.L.R., I*.
Strikers—	
M.L.M.C.	Common.
Studs—	
Clamping, slide, backsight, M.L.E.C.L.R., I*	Special to M.L.E.C.L.R., I*.
Clip, stop, magazine, M.L.E.R.S., I	Common.
Swivels—	
Band, M.L.M.R., II	Common.
Butt, M.L.M.R.	Common.
Piling, M.L.M.R., II	Common.
Traps, butt plate, M.L.M.R., II ..	Common.
Triggers, M.L.M.R., II	Common.
Wads, bolt, stock, M.L.M.	Common.
Washers—	
Bolt, stock	Common.
Guard, hand, or rivet, fore-end, M.L.M.	Common.
Screw, fixing, dial sight, M.L.M.R.	Common.
Windgauges, backsight, M.L.E.C.L.R., I*	Special to M.L.E.C.L.R., I*.

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CANADA. ROSS RIFLE.

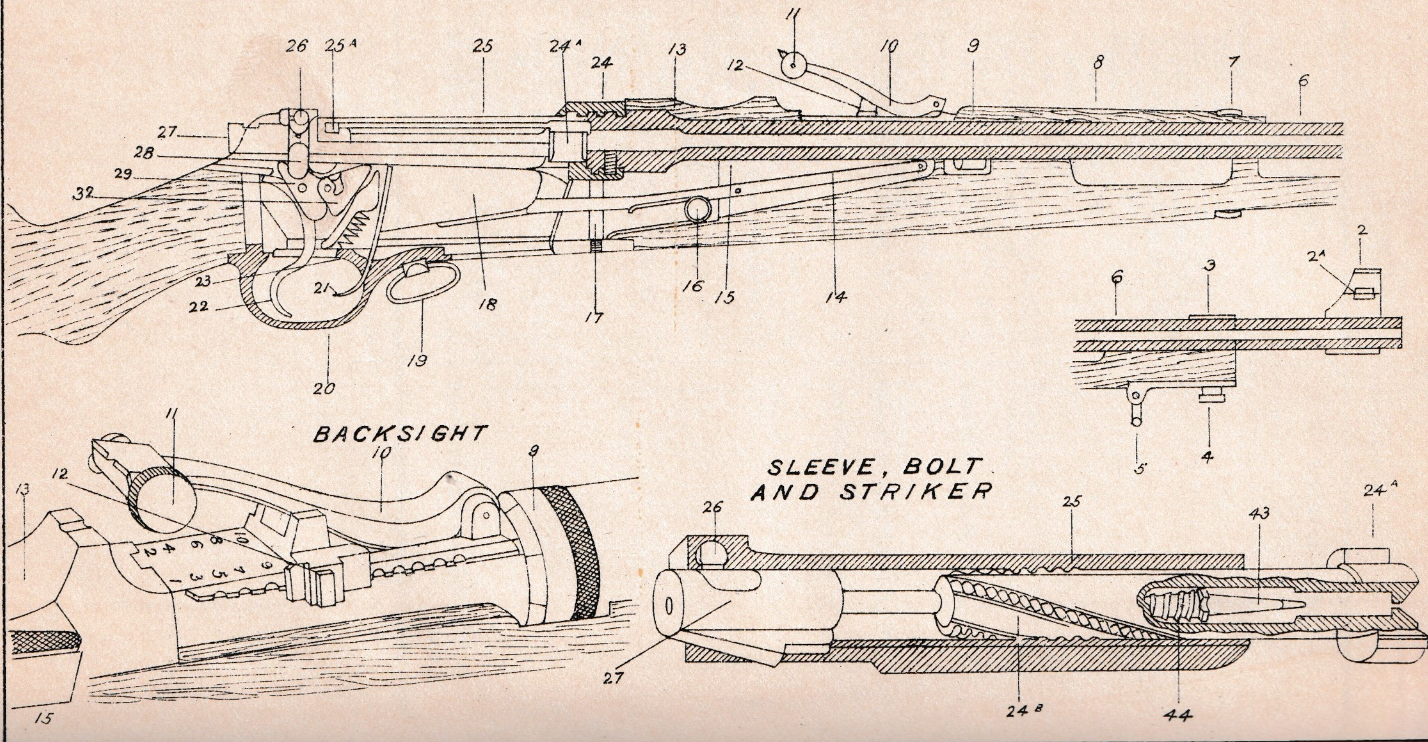

Plate A.

Weller & Graham, Ltd Litho London.

APPENDIX II.

CANADA.

Ross Rifle, Mark II, ·303-inch, 1907.

The action of this rifle is a modification of the Mauser.

The barrel (6) has a reinforce over the chamber, and is secured to the body (24) by a coarse left-handed screw-thread. The rifling consists of four concentric grooves with a right-handed twist of one turn in 10 inches. Barrel.

The foresight (2*a*) is a barleycorn dovetailed into a sleeve on the barrel, and protected by a hood (2). Sights.

The backsight, Mark III, consists of a U-shaped leaf (10), hinged at its front end to a ring called the sight leaf base, which surrounds the barrel. Two index slides, right and left, graduated from 100 to 2,200 yards, rest in a groove on the sight leaf base, and are supported in rear by slots in another ring, called the sight base ring. The height of the backsight leaf is regulated by the sight slide (12) which is mounted on the index slides, two horns on the sight slide bearing against the cam-shaped sides of the backsight leaf and thus giving the necessary elevation. Fine adjustment is obtained by the forward or backward movement of the index slides which carry the sight slide, and thus raise or lower the backsight leaf. The index slides are surrounded by a divided ring, the two parts of which are called the micrometer cams. The front edge of this ring is cam-shaped, and engages a projection on the right index slide in such a manner that the index slides are carried forward and back by the revolution of the micrometer cams. Another ring, called the micrometer thimble (9), revolving freely round the sight leaf base, engages the micrometer cams, and is graduated on its rear edge from 0 to 100, each graduation representing 10 yards of range. The revolving of the micrometer thimble revolves the micrometer cams, and thus moves the index slides. The backsight leaf is provided with a windgauge and a scale is marked on the leaf, each division of which represents roughly 4 inches per 100 yards.

The body (24) is screwed to the breech end of the barrel. Openings are provided on the top for the insertion of the cartridges, and at the bottom for the magazine (18), pawl (32), and sear (29). Inside are cut ribways to guide the bolt sleeve (25) and resisting shoulders to take the lugs (24*a*) on the bolt, and lock the rifle during discharge. The cam-shaped faces of the shoulders allow a rearward movement of the bolt during primary extraction. On the left are a slot for the ejector and ejector spring, a slot for the bolt stop, and a recess in which the safety catch (26) engages. Underneath are two bosses to take the sear pin and ejector pin. A cam pin in rear Body.

of the barrel thread gives the first turning movement to lock the bolt when closing the breech.

Attached to the body is the trigger-guard (20).

Bolt sleeve. The bolt sleeve (25) acts as a carrier for the bolt action. Its rear end is bent to form a handle, and is recessed to take the safety catch (26). Two ribs are formed to travel in the ribways in the body, the left rib having a lug at its front end to engage with the stop bolt. On the upper side are undercut grooves for the extractor (25*a*), and on the underside are two longitudinal ribs. A slot is cut at the rear end to guide the cocking piece. The inside is prepared with spirals similar to those on the bolt, which cause the turning movement necessary to lock the bolt.

Bolt. The bolt (24*a*) and bolt-head are in one piece, hollowed out to take the striker (43) and mainspring (44). Lugs on its front end engage with the resisting shoulders of the body to support the bolt on firing. The front face of the smaller lug is cam-shaped to effect primary extraction, the rear face of both lugs being similarly cammed to allow of this movement. Two spiral ribs (24*b*) give rotary movement to the bolt when actuated by the grooves in the bolt sleeve, the threads of the ribs and grooves preventing any tendency of the bolt to turn during the opening or closing of the breech. Two short spirals are formed at the rear end of the bolt, which, coming in contact with opposing faces on the bolt sleeve, ensure the threads of the long spirals correctly engaging those in the bolt sleeve. A cam slot is cut on the front end of the bolt to operate the ejector. The face of the bolt-head is recessed to centre the cartridge. The rear edge of the bolt-head is cammed in order to tighten the grip of the extractor on the cartridge while the bolt is being unlocked. There is a gas escape hole underneath the bolt-head. The interior of the bolt has a shoulder to engage the collar of the striker, and is threaded at its rear end to receive the mainspring retainer, a groove being left for the nib on the washer which secures the latter.

Mainspring. The mainspring (44) consists of 53 coils of ·032-inch wire, set to a length of $7\frac{3}{8}$ inches.

Striker. The striker (43) passes through the bolt, and is provided with a collar for the mainspring to bear against. Its rear end screws into the cocking piece (27). It is prevented from unscrewing by two flats cut on the threads, against one of which the cocking piece plunger bears.

Cocking piece. The cocking piece (27) is prepared to receive the striker. Externally it is cut away at the front and rear ends to form seatings for the safety catch (26). A pointed pin, called the cocking piece plunger, is screwed into the left side. This plunger engages one of the flats on the striker. A projecting rib on the underside of the cocking piece travels along the slot in the bolt sleeve, and keeps the cocking piece from turning. On this rib is a bent to engage the nose of the sear (29), and hold the striker at full cock.

The safety catch (26) consists of a bolt with a milled knob. The safety catch plunger, actuated by its spring, engages two grooves, cut transversely, in a flat on the underside of the safety catch, to prevent accidental slipping of the catch from the locked and unlocked positions. On the rear surface is a cam which engages the front of the cocking piece, and withdraws the bent from the nose of the sear when the action is placed at safety. The right end of the safety catch is cut so as to come flush with the bolt sleeve when assembled, and the left end acts as a locking bolt by engaging with a flat in the body, and thus preventing the opening of the bolt when set at safety. Safety catch.

The ejector is a flat piece of steel working in a slot in the left of the body. A spring presses its point inwards towards the bolt. It is withdrawn when the rifle is being loaded by the action of a cam on the left side of the bolt, but its pointed front end intercepts and ejects the empty case when the bolt is withdrawn. Ejector.

The extractor (25*a*) is a steel claw with a lug on its underside to engage the rear edge of the bolt-head and take the resistance during extraction. This lug prevents the extractor dropping out when the bolt is not in the rifle. Two undercut grooves on the upper surface of the extractor secure it to the bolt sleeve. It also prevents the bolt-head from turning beyond its pathway when the bolt lugs are unlocked. The claw springs over the rim of the cartridge when the bolt is closed. Extractor.

The sear (29) is a triangular piece of steel fitting inside the pawl (32), to which it is attached by a pin. It carries the trigger on an axis pin, and is recessed for the sear and pawl springs. Its rear angle forms the nose to take the bent of the cocking piece. Sear.

The pawl is a triangular piece of steel recessed to form a seating for the pawl spring. Pawl.

The trigger (22) is a bent lever pivoted to the sear. Its long arm forms a finger grip, and its short arm bears against the bottom of the body to lever the sear from the cocking piece when the trigger is pressed. Trigger.

The magazine (18) is a vertical box enclosed by the stock and fastened to the trigger guard by two screws. The front end is left open to allow of the movement of the lifter (14). Magazine.

The lifter (14) is a long steel bar working inside the magazine, with the magazine platform riveted to its rear end. It is situated below the barrel and is pivoted to the stock at its front end. A finger piece (15) rivetted to the centre projects from the right of the stock, and enables the lifter to be worked up and down against a spring (16). Lifter.

The cut-off is a steel stem, with a hook (21) for the thumb, passing behind the magazine and through the top of the trigger guard. A projection in front forms a bent, which, engaging in a slot in the trigger guard, holds it in the downward position. A projection in rear forms a seating for the cut-off spring. The top of the cut-off has two horns which lie over the Cut-off.

magazine platform, and are kept in place by slots in the rear end of the magazine.

Bolt stop. The bolt stop works in a seating on the left side of the body. It intercepts the lug on the front end of the bolt sleeve, and prevents it being withdrawn until the bolt stop is pressed down.

Trigger guard. The trigger guard (20) is of the usual shape and is screwed to the body. It forms the base of the magazine. In front of the trigger bow a swivel (19) is pivoted.

Butt plate and trap. The butt plate is secured by two screws. The hole for oil bottle and pull-through is closed by the butt trap with spring.

Bands. The front band (3) slips over the barrel, and is secured to the stock by a screw. A bayonet stud (4) and piling swivel (5) are screwed to the underside. The rear band (7) encircles the front handguard and stock, and is secured by a screw.

Stock. The stock is of walnut, in one piece, and is grooved to take the barrel, body, and magazine. It is hollowed at various portions for lightness. The usual clearance is provided for the barrel, and the butt has a pistol grip, a hole for the oil bottle and pull-through, and a swivel on the underside.

Action of the bolt mechanism. On drawing back the bolt sleeve a rotary motion is imparted to the bolt by means of the spirals, and the bolt is forced back by the cam of the small lug bearing against the body, thus effecting primary extraction. When the lugs on the bolt become disengaged from the shoulders on the body the threads on the bolt and sleeve engage, thus transferring the weight of the mainspring to the latter. On further drawing back the bolt the extractor draws back the empty case; the turning of the bolt causes the extractor to grip the case more firmly by the action of the cam on the lug of the extractor, and the projecting rims of the bolt-head prevent the case from falling away from the extractor claw. The ejector then intercepts the case and throws it out to the right. At the same time the cocking piece and striker are withdrawn by the sleeve, and the mainspring is compressed by the locking of the threads on the bolt and sleeve.

On pushing forward the bolt and sleeve the nose of the sear engages the bent of the cocking piece and takes the weight of the mainspring, and a cartridge is pushed into the chamber. The cam pin of the body turns the threads of the bolt from those of the sleeve and the bolt is locked by the spirals of the sleeve, the cocking piece and striker being held by the sear.

On pressing the trigger the sear is released, the cocking piece and striker fly forward, under the action of the mainspring, and fire the cartridge. The pressing of the trigger allows the pawl to rise and prevent any movement of the sleeve at the instant of firing. When the trigger is released the pawl returns to the normal position.

The action can be locked in the fired or cocked position by pressing the safety catch to the left.

The magazine can be filled by depressing the finger-piece of the lifter.

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